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CUMBERLANDIAN MOLLUSK CONSERVATION PROGRAM

ACTIVITY 7:
Analysis of Plant and Plankton Factors

Office of Natural Resources and Economic Development
Tennessee Valley Authority
Knoxville, Tennessee 37902

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COMPLETED

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TENNESSEE VALLEY AUTHORITY
Office of Natural Resources
Division of Water Resources

CUMBERLANDIAN MOLLUSK CONSERVATION PROGRAM

Activity 7:

Analysis of Plant and Plankton Factors

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TABLE OF CONTENTS

Page

Introduction 1

Materials and Methods. 2
  Field 2
  Laboratory. 6
  Data Analysis 8

Results and Discussion 10
  Aquatic Macrophytes 10
    Abundance 14
    Community Structure 31
  Plankton, Organic Solids, and Periphyton. 36
    Phytoplankton Abundance 37
    Phytoplankton Community Structure 49
    Zooplankton Abundance 66
    Zooplankton Community Structure 70
    Organic Solids 85
    Periphyton Abundance. 93
    Periphyton Community Structure. 95

Summary and Conclusions. 110
  Aquatic Macrophytes 110
    Abundance 110
    Community Structure 110
  Plankton, Organic Solids, and Periphyton. 111
    Abundance 111
    Community Structure 112

Appendices

A Aquatic Macrophytes Along River Reaches Being Investigated as Cumberlandian Mollusk Conservation Program Transplant Sites. A-1 118
B Growth Form and Species Percentages at Cumberlandian Mollusk Conservation Program Study Reaches B-1 124
C Total Phytoplankton Abundance (no/1 x 10^3), Cumberlandian Mollusk Conservation Program, 1980 and 1931. . . . . C-1 127
D Phytoplankton Abundance (no./ℓ x 10^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981. . D-1 130
E Total Zooplankton Abundance (no/m^3), Cumberlandian Mollusk Conservation Program, 1980 and 1981. . . . . E-1 145
F Zooplankton Abundance (no/m^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981. . . . . F-1 148
G Suspended Solids Data Collected from Surface and Near Bottom Depths at 15 Designated Study Reaches, Cumberlandian Mollusk Conservation Program, 1980 and 1981. . . . . G-1 153
H Volatile Solids Data Collected from Surface and Near Bottom Depths of 15 Designated Study Reaches, Cumberlandian Mollusk Conservation Program, 1980 and 1981. . . . . H-1 156
I Total Periphyton Abundance (no./cm^2 x 10^3), Cumberlandian Mollusk Conservation Program, 1980 and 1981. . . . . I-1 159
J Periphyton Abundance (no./cm^2 x 10^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981. . J-1 162

LIST OF TABLES

Table **Page**

1 Submersed/Floating-Leaved Vascular Plants, Bryophytes, and Macroscopic Algae Along River Reaches Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program 11

2 Emergent Macrophytes along River Reaches Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program 13

3 Percentage of Reaches Colonized by Emergent, Submersed/Floating-Leaved, and Composite Vegetation, Cumberlandian Mollusk Conservation Program 30

4 Submersed/Floating-Leaved Vascular Plants, Bryophytes, and Macroscopic Algae Along River Systems Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Cumberlandian Program 34

5 Emergent Macrophytes Along River Systems Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program 35

6 Algae Genera Found in Mussel Gut Contents (After Allen, 1914) 38

7 T-Test for Depth (Surface and Near Bottom) Differences of Phytoplankton at Each Designated Study Reach, Cumberlandian Mollusk Conservation Program, 1980 and 1981 43

8 Phytoplankton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981 46

9 Phytoplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected) 51

10 Phytoplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, April through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected) 60

11 Zooplankton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981 71

12 Zooplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.) 72

LIST OF TABLES (Continued)

Table | Page

13 Zooplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, April through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.) 80

14 T-Test for Depth (Surface and Near Bottom) Differences of Suspended and Volatile Solids at Each Designated Study Reach, Cumberlandian Mollusk Conservation Program, 1980 and 1981 . . 86

15 Suspended and Volatile Solids One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981 92

16 Periphyton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981. 94

17 Periphyton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.). 98

18 Periphyton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, June through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.). 104

iv

LIST OF FIGURES

Figure		Page
1	Aquatic Macrophyte Communities at Topsy Bridge - Buffalo River, Cumberlandian Mollusk Conservation Program	15
2	Aquatic Macrophyte Communities at Mile 60 - Paint Rock River, Cumberlandian Mollusk Conservation Program.	16
3	Aquatic Macrophyte Communities at Lillards Mill - Duck River, Cumberlandian Mollusk Conservation Program.	17
4	Aquatic Macrophyte Communities at Sowell Ford - Duck River, Cumberlandian Mollusk Conservation Program.	18
5	Aquatic Macrophyte Communities at Halls Mill - Duck River, Cumberlandian Mollusk Conservation Program.	19
6	Aquatic Macrophyte Communities at Dement Bridge - Duck River, Cumberlandian Mollusk Conservation Program	20
7	Aquatic Macrophyte Communities at Mile 91.4 - Elk River, Cumberlandian Mollusk Conservation Program.	21
8	Aquatic Macrophyte Communities at Fort Blackmore - Clinch River, Cumberlandian Mollusk Conservation Program	22
9	Aquatic Macrophyte Communities at Kyles Ford - Clinch River, Cumberlandian Mollusk Conservation Program	23
10	Aquatic Macrophyte Communities at Mile 1.9 - Copper Creek, Cumberlandian Mollusk Conservation Program.	24
11	Aquatic Macrophyte Communities at Hale Bridge - Nolichucky River, Cumberlandian Mollusk Conservation Program	25
12	Aquatic Macrophyte Communities at Click Island - North Fork Holston River, Cumberlandian Mollusk Conservation Program	26
13	Aquatic Macrophyte Communities at Saltville - North Fork Holston River, Cumberlandian Mollusk Conservation Program . .	27
14	Aquatic Macrophyte Communities at Buchanan Ford - Powell River, Cumberlandian Mollusk Conservation Program	28
15	Aquatic Macrophyte Communities at Fletcher Ford - Powell River, Cumberlandian Mollusk Conservation Program	29

V

LIST OF FIGURES (Continued)

Figure		Page
16	Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Submersed/Floating-Leaved and Emergent Taxa Along River Reaches, Cumberlandian Mollusk Conservation Program . .	32
17	Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Submersed/Floating-Leaved and Emergent Taxa Along River Systems, Cumberlandian Mollusk Conservation Program . .	32
18	Monthly Phytoplankton Abundance at the Near-Surface Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980	39
19	Monthly Phytoplankton Abundance at the Near-Bottom Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980	40
20	Monthly Phytoplankton Abundance at the Near-Surface Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981	41
21	Monthly Phytoplankton Abundance at the Near-Bottom Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981	42
22	Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Phytoplankton Taxa Collected at Study Reaches, July through September 1980, Cumberlandian Mollusk Conservation Program	50
23	Comparison of Study Reaches Based Upon the First and Second Principal Components of Phytoplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program	55
24	Comparison of Study Reaches Based Upon the Second and Third Principal Components of Phytoplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program	57
25	Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Phytoplankton Taxa Collected at Study Reaches, April through September 1981, Cumberlandian Mollusk Conservation Program	58
26	Comparison of Study Reaches Based Upon the First and Second Principal Components of Phytoplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program	63

vi

LIST OF FIGURES (Continued)

Figure Page

27 Comparison of Study Reaches Based Upon the Second and Third Principal Components of Phytoplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program 65

28 Monthly Zooplankton Abundance at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980 67

29 Monthly Zooplankton Abundance at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981 68

30 Monthly Zooplankton Abundance at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981 (April Data at DRM 243.1 Deleted to Better Illustrate Differences Among Other Sites) 69

31 Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Zooplankton Taxa Collected at Study Reaches, July through September 1980, Cumberlandian Mollusk Conservation Program 74

32 Comparison of Study Reaches Based Upon the First and Third Principal Components of Zooplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program 76

33 Comparison of Study Reaches Based Upon the Second and Third Principal Components of Zooplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program 77

34 Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Zooplankton Taxa Collected at Study Reaches, April through September 1981, Cumberlandian Mollusk Conservation Program 79

35 Comparison of Study Reaches Based Upon the First and Second Principal Components of Zooplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program 83

36 Comparison of Study Reaches Based Upon the Second and Third Principal Components of Zooplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program 84

37 Monthly Suspended Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980 . . 88

LIST OF FIGURES (Continued)

Figure | Page

38 Monthly Suspended Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981 . . 89

39 Monthly Volatile Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980 . . 90

40 Monthly Volatile Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981 . . 91

41 Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Periphyton Taxa Collected at Study Reaches, July through September 1980, Cumberlandian Mollusk Conservation Program 96

42 Comparison of Study Reaches Based Upon the First and Third Principal Components of Periphyton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program 100

43 Comparison of Study Reaches Based Upon the Second and Third Principal Components of Periphyton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program 102

44 Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Periphyton Taxa Collected at Study Reaches, June through September 1981, Cumberlandian Mollusk Conservation Program 103

45 Comparison of Study Reaches Based Upon the First and Third Principal Components of Periphyton Data Collected June through September 1981, Cumberlandian Mollusk Conservation Program 107

46 Comparison of Study Reaches Based Upon the Second and Third Principal Components of Periphyton Data Collected June through September 1981, Cumberlandian Mollusk Conservation Program 109

ACTIVITY 7 REPORT

PLANT AND PLANKTON ANALYSES OF DESIGNATED STUDY REACHES, CUMBERLANDIAN MOLLUSK CONSERVATION PROGRAM

1980 AND 1981

INTRODUCTION

While exact requirements for successful mussel reproduction and survival vary for individual species and are not completely understood, general considerations for establishing a successful transplant should include: (1) substrate composition, stability, and availability; (2) stream hydrology and topography; (3) water quality; (4) presence of host fish and associated ecological requirements; and (5) stream nutrition or trophic status. The purpose of this report is to provide insight to importance of (1) emergent and submersed aquatic macrophytes relative to substrate stability and host fish ecology, (2) phytoplankton, zooplankton, and periphyton abundance relative to mussel nutritional requirements, and (3) aquatic macrophyte, plankton, and periphyton community structures relative to comparing ecological similarities among designated study areas. Study areas are also contrasted based on suspended organic solids information.

MATERIALS AND METHODS

Areas selected for study were comprised of 200-meter long stream reaches at 15 locations representing the Buffalo, Paint Rock, Duck, Elk, Clinch, Nolichucky, North Fork Holston, and Powell Rivers. Areas of these rivers beyond the 200-meter long reach limits were also evaluated qualitatively to describe aquatic macrophyte distributions.

FIELD

Aquatic Macrophytes

The term aquatic macrophyte refers to the larger aquatic plants and includes macroalgae, mosses, liverworts, and vascular species (ferns and flowering plants). Aquatic macrophyte communities upstream and downstream of each study reach (referred to as river reaches) were qualitatively sampled by conducting boat surveys along several miles of river during the mid- to late-growing season (e.g., July through September). In instances where the stream was too shallow for boat surveys (e.g., Copper Creek), selected stream portions near access points were qualitatively sampled for aquatic macrophytes. Voucher specimens were collected, prepared according to standard methods (Wood, 1975), and returned to the laboratory for identification.

Aquatic macrophyte communities at each study reach were mapped with survey instruments (alidade and plane table) or by determining the distance from range points along a baseline to boundaries of macrophyte communities using a steel cable or tape. The various communities were enumerated on the basis of dominant or codominant species. In the case of submersed/floating-leaved macrophyte communities, estimates of percent coverage were made in the field and recorded on maps of each study reach.

Aquatic macrophyte communities may be divided into several classes based on their growth form. For the purpose of this study, three macrophyte communities are recognized: woody, emergent, and submersed/floating-leaved. Woody communities include shrubs and trees, while emergent includes herbaceous species that are rooted in saturated soils or those covered by water. Emergent species have upright vegetative shoots that extend above the surface of the water. Species whose vegetative structures grow entirely under the water are classified as submersed. Floating-leaved species are similar to submersed but differ in having floating leaves.

Phytoplankton

The phytoplankton community at each designated study reach was sampled with an 8-liter Van Dorn water sampler and a 10-liter plastic bucket. A pool habitat at each reach was selected for sampling. Surface samples were collected by submersing the plastic bucket just under the water surface (0-0.3 meter) and then using this water to fill the required sample container. Near-bottom samples were collected by submersing the 8-liter Van Dorn water sampler to within 0.3 meter of the bottom, holding it parallel to the bottom and current, and triggering it closed. Water was emptied from the Van Dorn sampler into the plastic bucket for filling each sample container.

Phytoplankton samples were collected from each study reach at monthly intervals, July through September 1980 and April through September 1981. (In 1981, May collections were made at only two reaches on the Buffalo and Paint Rock Rivers.) Two samples were collected from near surface and again from near bottom of the stream at each study reach to provide information about community structure and standing crop. Utilizing plankton sampling procedures described above, 150-ml (dark) Nalgene bottles were filled and preserved with Lugols solution (5 percent final concentration). Replicate samples were not taken from the same bucket of river water. Following preservation, each sample was closed tightly, labeled as to stream, location, depth, date, and collector, and sent to the Aquatic Biology Laboratory Unit (ABLU) at Muscle Shoals, Alabama, for analysis.

Zooplankton

Zooplankton samples also were collected at monthly intervals, July through September 1980 and April through September 1981. (In 1981, May collections were made only at two sites on the Paint Rock and Buffalo Rivers.) Two samples were collected from each designated study reach. Each sample, consisting of 60 liters of river water, was poured through a Wisconsin plankton net (No. 20 mesh, 80-μm netting). Net contents were rinsed into a 125-ml widemouth Nalgene bottle and preserved in 10-percent formalin (final concentration). Half of each 60-liter sample was taken from the near-surface and the other half was taken from the near-bottom depth. Samples were labeled as to stream, location, habitat, date, and collector and were sent to the ABLU at Muscle Shoals, Alabama, for analysis.

Organic Solids

Two replicate samples for solids determination were collected from each of the near-surface and near-bottom depths at all designated study reaches. These samples were collected at the same times and locations as phytoplankton samples. A sample consisted of up to 5 liters of river water which was vacuum filtered through a preweighed glass fiber filter provided by the Laboratory Branch, Chattanooga, Tennessee. As much of the 5 liters as possible was filtered to provide an adequate sample. All samples were sent to the Laboratory Branch for a standard suspended solids/volatile solids determination. Each sample sent to the Laboratory Branch was labeled as to stream, location, depth, date, collector, and volume filtered.

Periphyton

Three replicate periphyton samples were collected at each study reach in July and September 1980 and May-June, July, and September 1981. In 1981, samples were collected in June instead of May at most reaches due to scheduling difficulties. Because factors such as flow, water depth, and light drastically affect abundance and diversity of the periphyton, sampling locations at the 15 reaches were selected from similar habitats.

All stones at the water/substrate interface within a 25-cm by 25-cm grid were placed into an appropriate size glass or Nalgene container, covered with a measured volume of distilled water, and inoculated with Lugols solution to attain a final concentration of 5 percent by volume. The area from which periphyton was collected contained rocks (not bedrock) and was exposed to direct sunlight (e.g., firm substrate just upstream of riffle areas). Each sample container was tightly closed, labeled by station, location, water depth, date, and collector, and sent to the laboratory at Muscle Shoals for periphyton identification and enumeration.

LABORATORY

Aquatic Macrophytes

Specimens of vascular aquatic macrophytes were identified in the laboratory using the following series of references: Gleason (1952), Radford *et al*. (1968), Beal (1977), and Godfrey and Wooten (1979, 1981). Moss and liverwort specimens were identified by a bryologist retained as a consultant.

Data collected in the field for mapping macrophyte communities were transferred to clean base maps and later reduced to a size suitable for a report. Areal coverage of each community for each study reach was determined using an electronic planimeter.

Phytoplankton

Phytoplankton samples were processed for identification and enumeration by agitating each sample, placing a 15-ml aliquot in a counting chamber, and allowing a minimum of 12 hours for settling. Algal cells were identified and enumerated at the generic level with an inverted microscope (usually 320X magnification). References and publications used in identification included: Cocke (1967), Desikachary (1959), Drovet (1973), Drovet and Daily (1973), Forest (1954), Hustedt (1930), Patrick and Reimer (1966), Prescott (1962, 1964), Smith (1933), Tiffany and Britton (1971), and Whitford and Schumacher (1969).

Zooplankton

Zooplankton samples were diluted or concentrated, depending on abundance of detritus and organisms. Four 1-ml subsamples were taken from the magnetically stirred sample with a 1-ml Hensen-Stemple pipette and placed in a Sedgwick Rafter cell. Organisms were enumerated at the lowest practicable taxonomic level, usually species, with a compound microscope at 35X or 50X magnification. Following subsample enumeration, the remaining sample was scanned for organisms not encountered in subsampling using a dissecting microscope at 14X. References and publications used in identifications include: Ahlstrom (1940, 1943), Brooks (1957), Deevey and Deevey (1971), Goulden (1968), Harring and Myers (1926), Ruttner-Kolisco (1974), Voigt (1956) and Ward and Whipple (1959).

Organic Solids

Total suspended solids and volatile solids analyses were performed by the Laboratory Branch, Chattanooga, Tennessee, according to standard methodology (TVA, 1980).

Periphyton

Rock substrates returned to the ABLU were scraped to remove periphyton. Sample material was then processed as described above for phytoplankton.

DATA ANALYSIS

Aquatic Macrophytes

Measurement of similarity of the fifteen river reaches and nine drainage systems was made using the Jaccard coefficient of similarity (Jaccard, 1908) and clustered with an unweighted paired group using mathematical averages algorithm (UPGMA) as described by Sneath and Sokal (1973). This comparison is based on the presence/absence of taxa and utilizes submersed/floating-leaved and emergent macrophyte species along the river reaches and drainage systems investigated for this study. A composite listing for each river was obtained by combining the taxa from each study reach in that particular system.

In addition to a map of aquatic macrophyte communities at each site, percent areal coverage of emergent, submersed/floating-leaved, and woody communities was calculated and sites were ranked according to the calculated percentages. In the case of submersed/floating-leaved communities, areal coverage was calculated by multiplying the area colonized by a percent cover estimate made during field work.

Plankton, Organic Solids, and Periphyton

Solids and phytoplankton data sets including values taken at different depths were analyzed by performing t-tests of differences between two means (Freund, 1973). If significant differences were not found, all samples at a given site were treated as replicates in further tests. All enumeration data (phytoplankton, zooplankton, and periphyton) were log transformed and one-way analysis of variance (ANOVA) and Duncan's new multiple-range test (Steel and Torrie, 1960) were performed for each year to identify reaches similar in abundance for total organisms and major composing groups (phytoplankton and periphyton: Chrysophyta, Chlorophyta, and Cyanophyta; zooplankton: Rotifera, Cladocera, and Copepoda). Solids data were treated similarly, except untransformed data were used in statistical tests. Monthly data were also graphically demonstrated by site for each year.

The 15 study reaches were compared based on the presence/absence of phytoplankton, zooplankton, and periphyton taxa using Jaccard's coefficient (Jaccard, 1908) and clustered with an unweighted paired group using mathematical averages algorithm (UPGMA) as described by Sneath and Sokal (1973).

Study reaches were also contrasted for each community with a principal component analysis (PCA) using the PRINCOMP procedure (SAS, 1982). This procedure reduces the dimensionality of the original data matrix by transforming the data into a set of uncorrelated vector components, thereby summarizing the important patterns in a data set in terms of a few basic trends (components) which may account for a large portion of the variation (Mahloch, 1974). Data for PCA were normalized using base 10 logarithms.

RESULTS AND DISCUSSION

AQUATIC MACROPHYTES

Emergent and submersed/floating-leaved aquatic macrophytes occurring along reaches of river several miles above and below the study reaches are summarized in appendix A along with notes on their relative abundance.

Twelve species of submersed/floating-leaved vascular plants, four species of bryophytes and two species of macroscopic algae (table 1), were found along the river reaches investigated. Only two of these species are considered particularly noteworthy or indicators of unique ecological conditions. Potamogeton amplifolius Tuckerman, which occurs in the Paint Rock River, reaches the southern limit of its range in northern Alabama (Ogden, 1943) and is known from only one other county in the State (Haynes, 1980). The species is also rare in Tennessee (Patrick et al., 1983). Its presence in the Paint Rock likely indicates some unusual water quality parameter or possibly some unique factor in the past geologic history of the Paint Rock system. Another interesting species found in the Buffalo, Duck, Elk, and Nolichucky Rivers is riverweed or Podostemum ceratophyllum Michx. Meijer (1976) proposes riverweed as an indicator of "clean" water. However, Philbrick and Crow (1983) quesion whether it is as good an indicator as proposed by Meijer (1976).

Of the fifteen emergent taxa found in this study (table 2), only golden club (Orontium aquaticum L.) is considered unusual and warranting discussion. Golden club was found at a single locality along the Buffalo River. This locality extends the range reported by Grear (1966) and is

Table 1. Submersed/Floating-Leaved Vascular Plants, Bryophytes, and Macroscopic Algae Along River Reaches Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program

	Macrophyte Species																	
	Vascular Plants - Submersed/Floating - Leaved												Bryophytes				Macroscopic Algae	
Site	*Callitriche heterophylla*	*Ceratophyllum demersum*	*Elodea canadensis*	*Heteranthera dubia*	*Myriophyllum heterophyllum*	*Podostemum ceratophyllum*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton foliosus*	*Potamogeton nodosus*	*Potamogeton pectinatus*	*Vallisneria americana*	*Eurhynchium riparioides*	*Fissidens fontanus*	*Leptodictyum riparium*	*Porella pinnata*	*Chara* sp.	*Lemanea* sp.
Buffalo River - Topsy Bridge						X						X				X		
Paint Rock River - Mile 60					X		X	X	X						X	X	X	
Duck River - Lillards Mill			X	X					X	X				X		X		
Duck River - Sowell Ford				X		X				X				X		X		
Duck River - Halls Mill			X			X				X				X		X		
Duck River - Dement Bridge						X								X	X	X		
Elk River - Mile 91.4	X					X								X		X		
Clinch River - Fort Blackmore			X	X						X	X				X	X		
Clinch River - Kyles Ford				X						X		X			X	X		X
Copper Creek - Mile 1.9																X		
Nolichucky River - Hale Bridge			X			X							X	X		X		X
North Fork Holston River - Click Island			X	X						X	X	X				X		

(Continued)

Table 1. Continued

	Macrophyte Species																	
	Vascular Plants - Submersed/Floating - Leaved												Bryophytes				Macroscopic Algae	
Site	*Callitriche heterophylla*	*Ceratophyllum demersum*	*Elodea canadensis*	*Heteranthera dubia*	*Myriophyllum heterophyllum*	*Podostemum ceratophyllum*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton foliosus*	*Potamogeton nodosus*	*Potamogeton pectinatus*	*Vallisneria americana*	*Eurhynchium riparioides*	*Fissidens fontanus*	*Leptodictyum riparium*	*Porella pinnata*	*Chara* sp.	*Lemanea* sp.
North Fork Holston River - Saltville		X		X					X	X					X	X	X	
Powell River - Buchanan Ford										X	X					X		
Powell River - Fletcher Ford										X	X					X		X

Table 2. Emergent Macrophytes Along River Reaches Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program.

Site	*Decodon verticillata*	*Eleocharis palustris*	*Heteranthera reniformis*	*Iris pseudo-acorus*	*Justicia americana*	*Leersia oryzoides*	*Nasturtium officinale*	*Nuphar luteum*	*Onoclea sensibilis*	*Orontium aquaticum*	*Phalaris arundianacea*	*Sagittaria* sp.	*Saururus cernuus*	*Scirpus americanus*	*Scirpus validus*
Buffalo River - Topsy Bridge					X	X			X	X			X		
Paint Rock River - Mile 60					X	X		X							X
Duck River - Lillard's Mill					X	X							X		
Duck River - Sowell Ford					X	X									
Duck River - Hall's Mill					X	X							X	X	
Duck River - Dement Bridge	X				X	X	X						X		
Elk River - Mile 91.4			X		X	X	X								
Clinch River - Fort Blackmore					X	X					X			X	X
Clinch River - Kyles Ford		X			X	X							X	X	
Copper Creek - Mile 1.9					X	X									
Nolichucky River - Hales Bridge		X			X	X			X					X	X
North Fork Holston River - Click Island		X			X	X						X	X	X	X
North Fork Holston River - Saltville				X	X	X								X	X
Powell River - Fletcher Ford					X	X	X						X	X	
Powell River - Buchanan Ford		X			X	X							X	X	

noteworthy in that it represents a station in the Highland Rim section of the Interior Low Plateau for which Grear (1966) records no collections.

Abundance

Aquatic macrophyte communities at each study reach were mapped and are shown in figures 1 through 15. Percent cover of each species and a tabulation by growth form (woody, emergent, submersed/floating-leaved) is contained in appendix B. Emergent communities would seem to be important to mussel populations in that they function to stabilize the substrate and prevent meandering of instream channels. In addition to substrate stabilization, emergent and submersed/floating-leaved macrophytes probably are important in that they provide structure and spawning areas which attract fish species.

A comparison of the present emergent vegetation (table 3) at the study reaches shows that nine reaches (Hale Bridge, Paint Rock, Saltville, Fort Blackmore, Fletcher Ford, Kyles Ford, Buchanan Ford, Halls Mill, and Lillards Mill) exceed 10-percent coverage. The Hale Bridge study reach had substantially more emergent vegetation (42.0%) than any of the other study reaches. In regards to submersed/floating-leaved vegetation (table 3) only five study reaches (Click Island, Lillards Mill, Sowell Ford, Paint Rock River, and Buffalo River) had more than 2-percent coverage. One study reach (Click Island) had 43.2 percent coverage which substantially exceeds submersed/floating-leaved vegetation at other study reaches. Woody vegetation at the

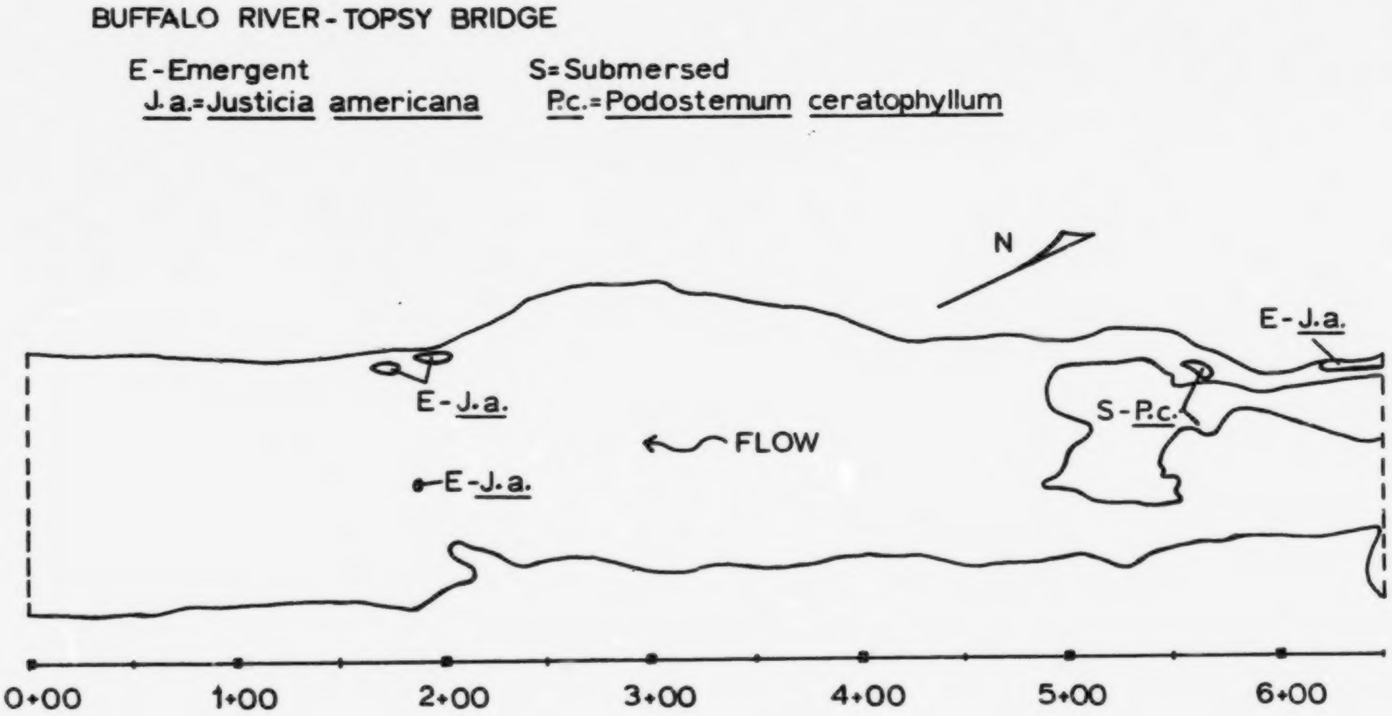

Figure 1. Aquatic Macrophyte Communities at Topsy Bridge - Buffalo River, Cumberlandian Mollusk Conservation Program.

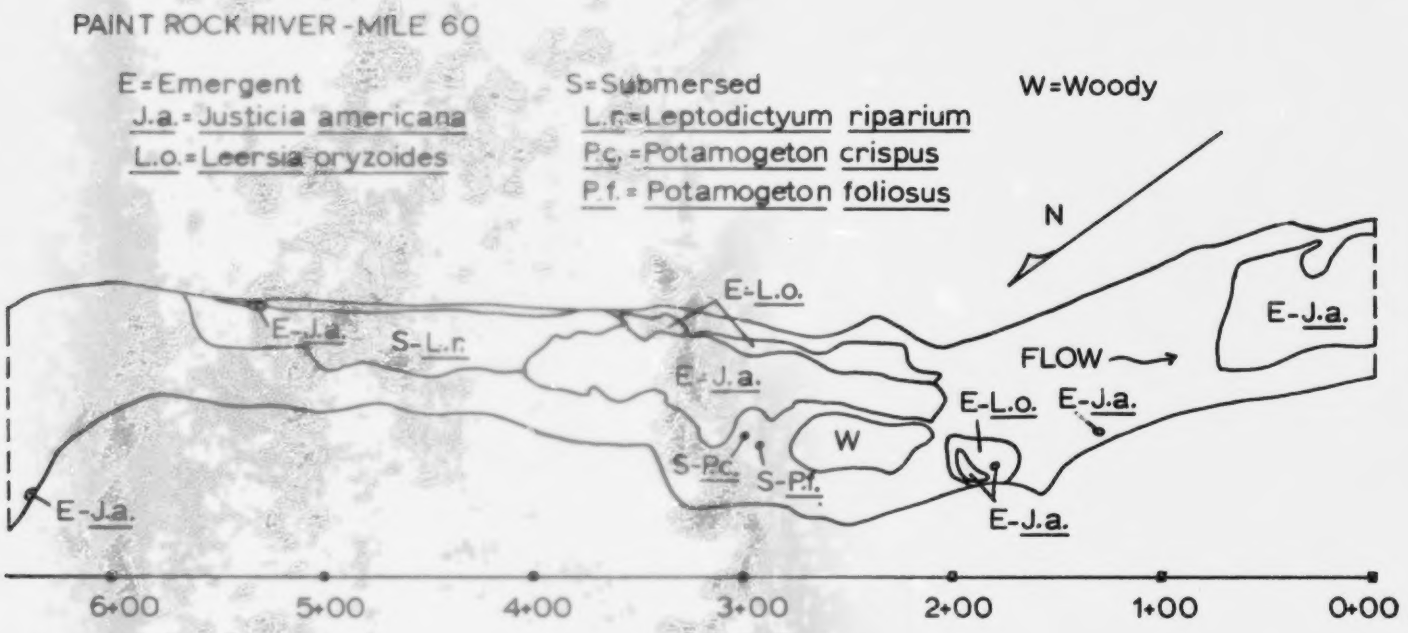

Figure 2. Aquatic Macrophyte Communities at Mile 60 - Paint Rock River, Cumberlandian Mollusk Conservation Program.

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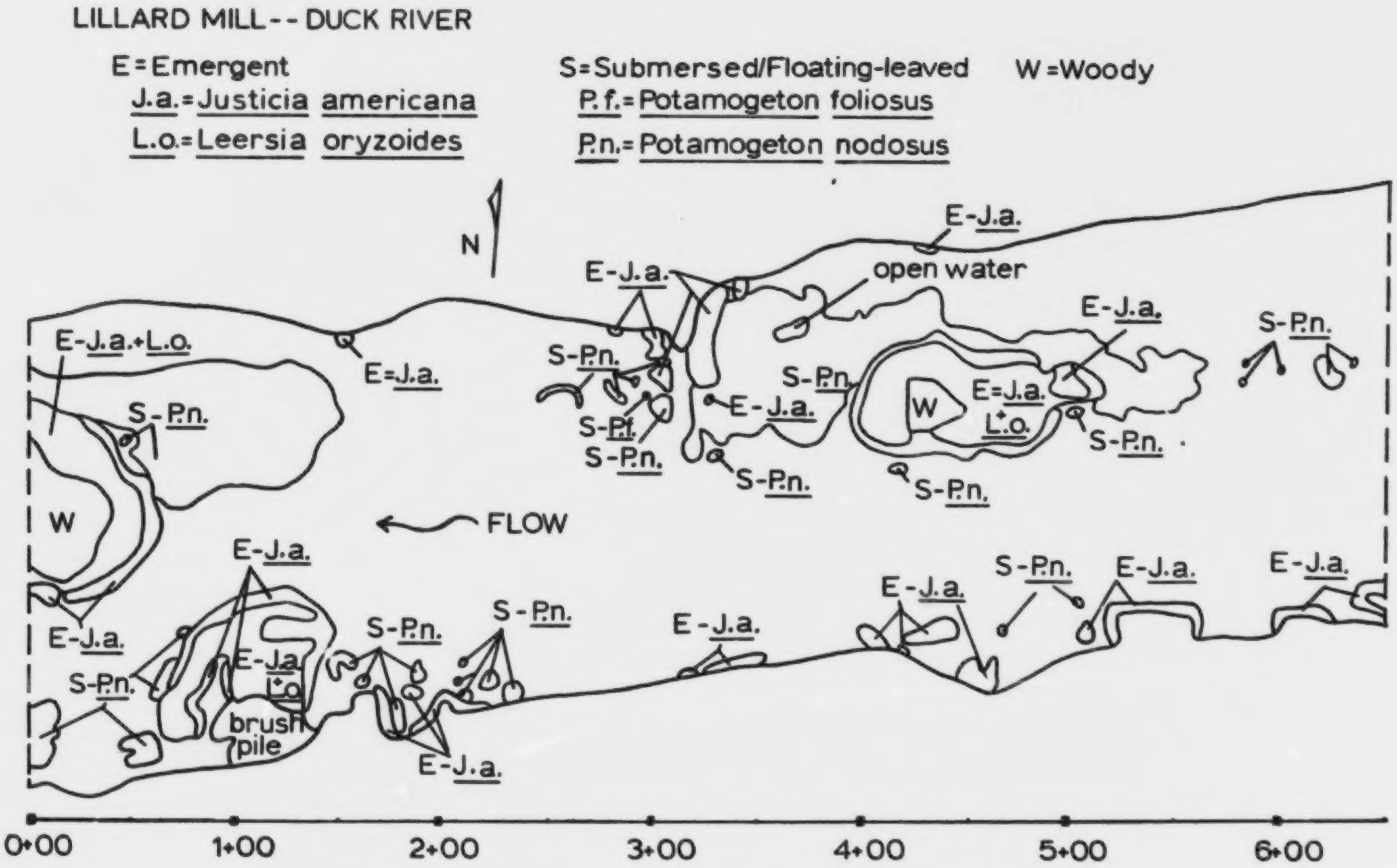

Figure 3. Aquatic Macrophyte Communities at Lillards Mill - Duck River, Cumberlandian Mollusk Conservation Program.

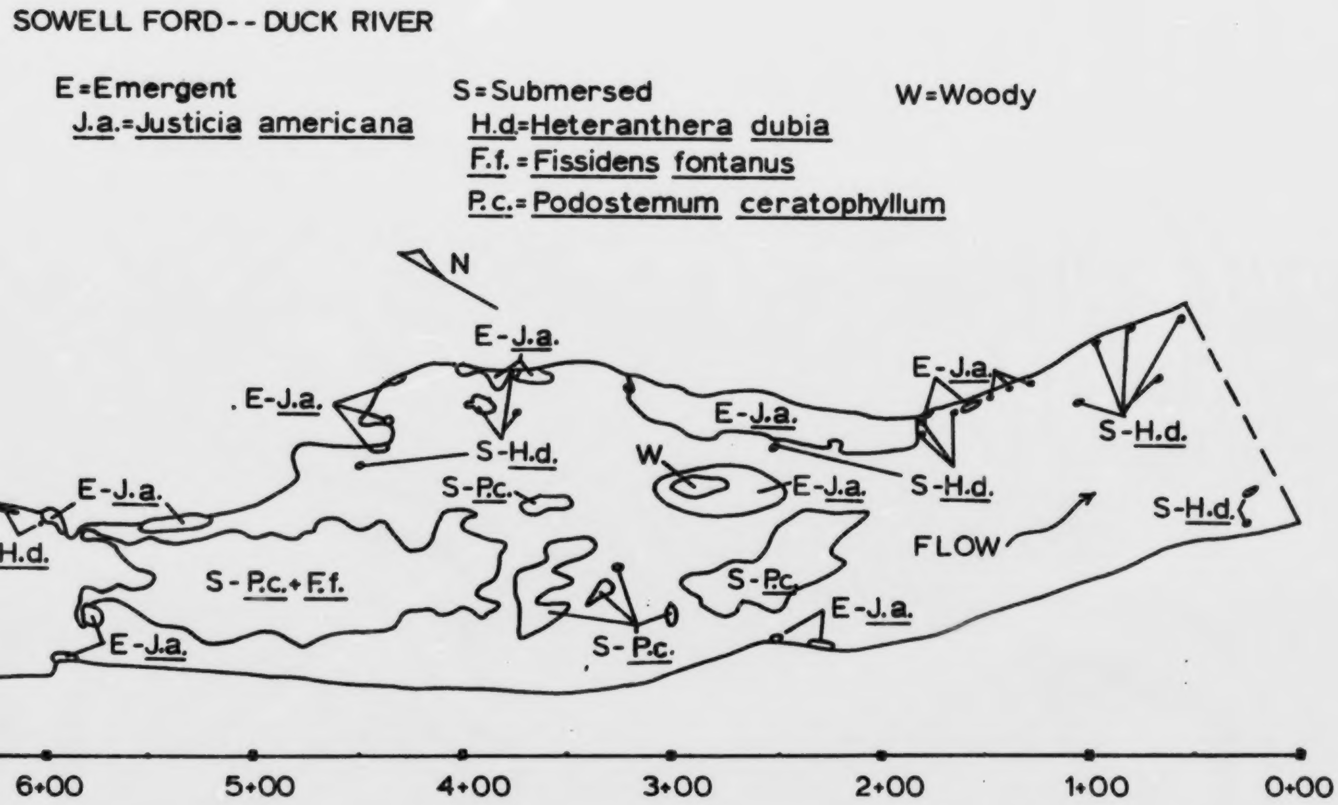

Figure 4. Aquatic Macrophyte Communities at Sowell Ford - Duck River, Cumberlandian Mollusk Conservation Program.

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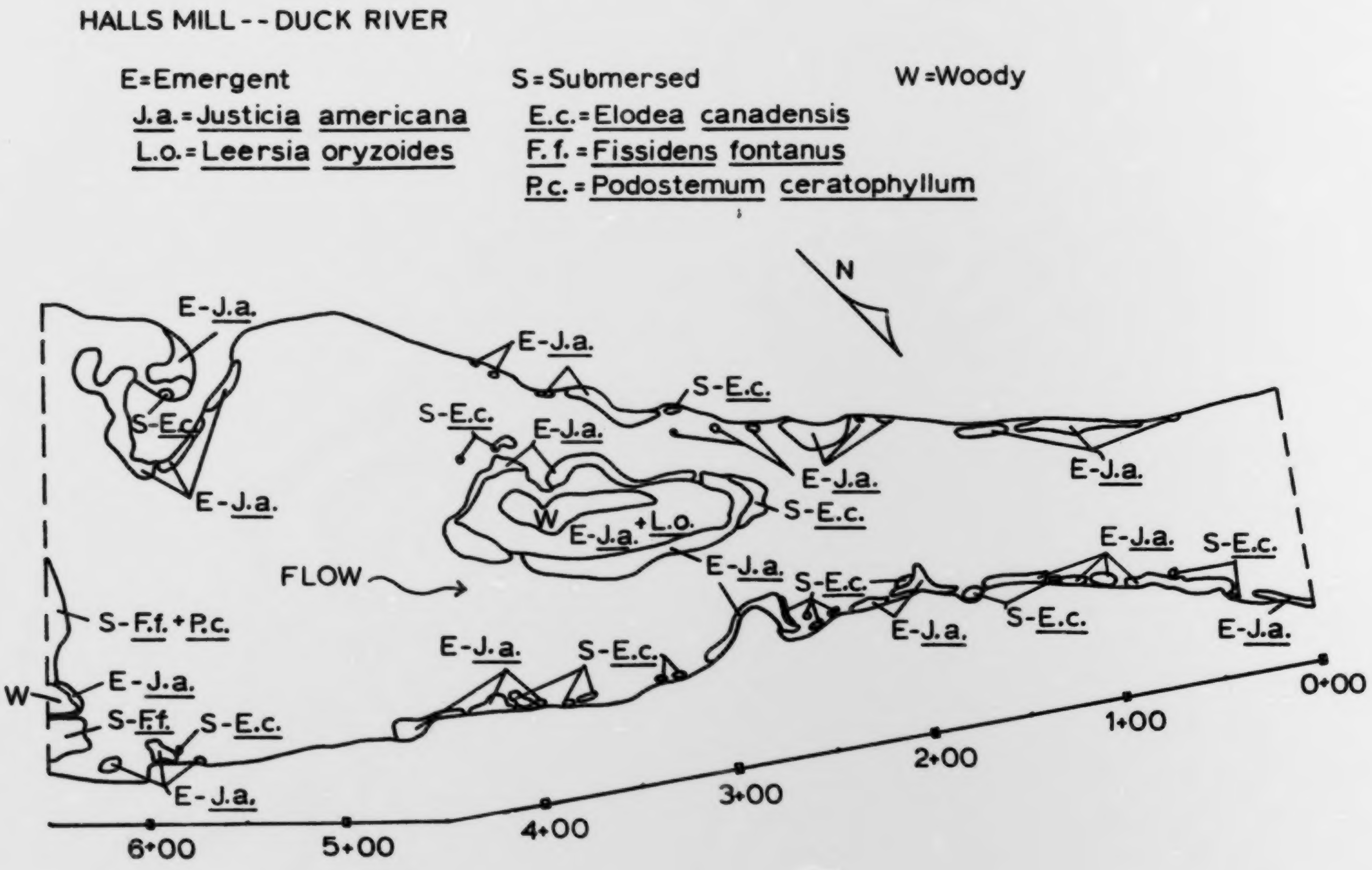

Figure 5. Aquatic Macrophyte Communities at Halls Mill - Duck River, Cumberlandian Mollusk Conservation Program.

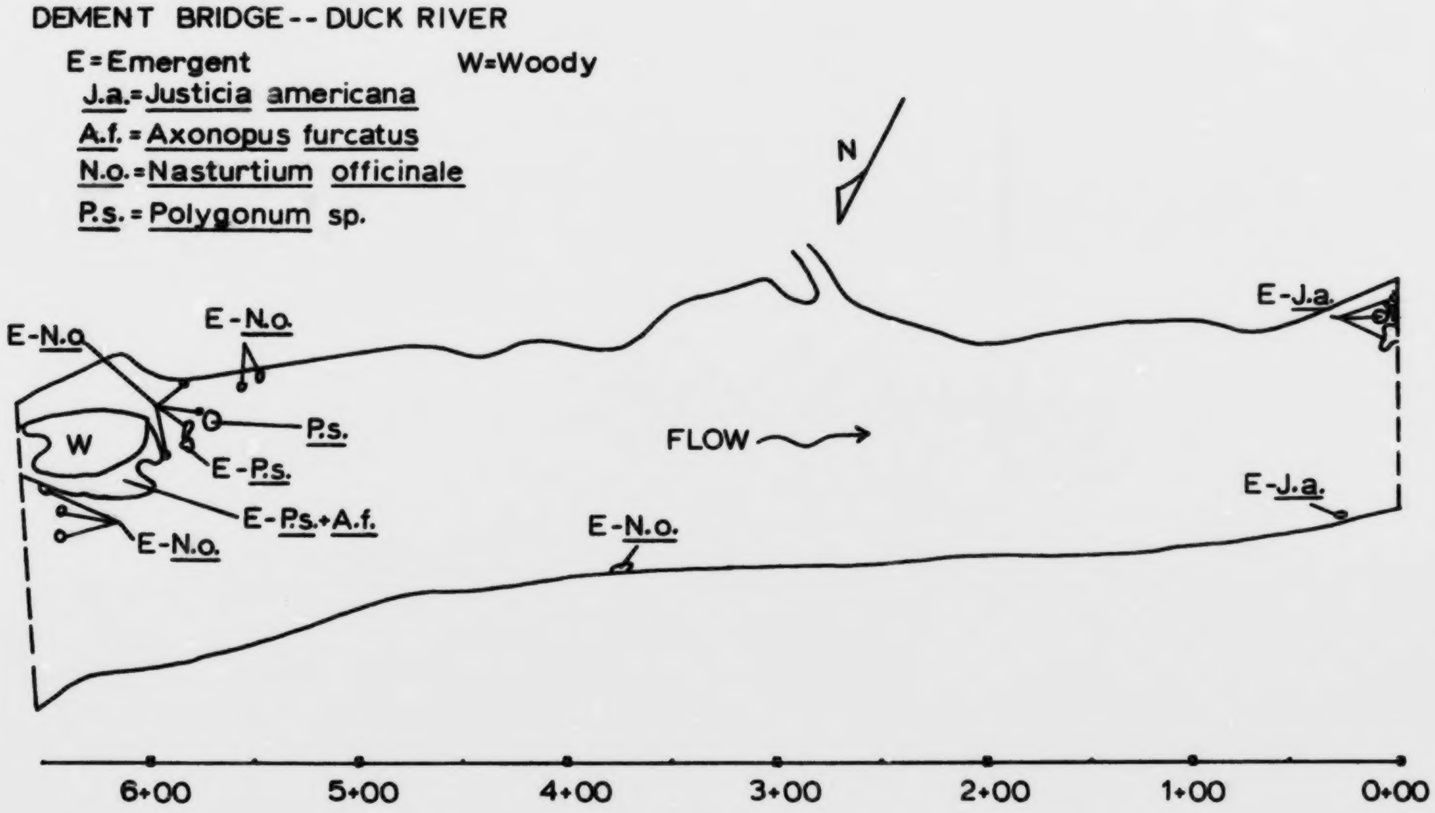

Figure 6. Aquatic Macrophyte Communities at Dement Bridge - Duck River, Cumberlandian Mollusk Conservation Program.

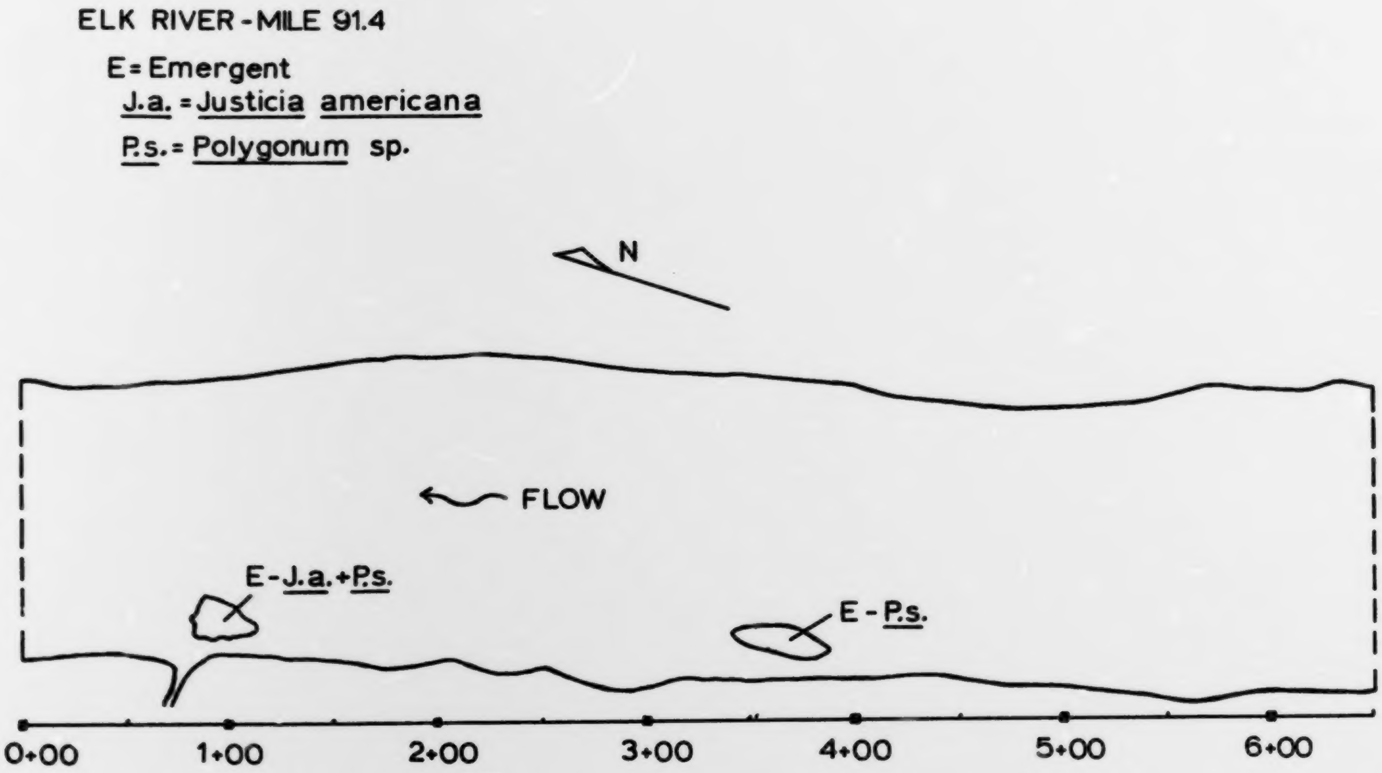

Figure 7. Aquatic Macrophyte Communities at Mile 91.4 - Elk River, Cumberlandian Mollusk Conservation Program.

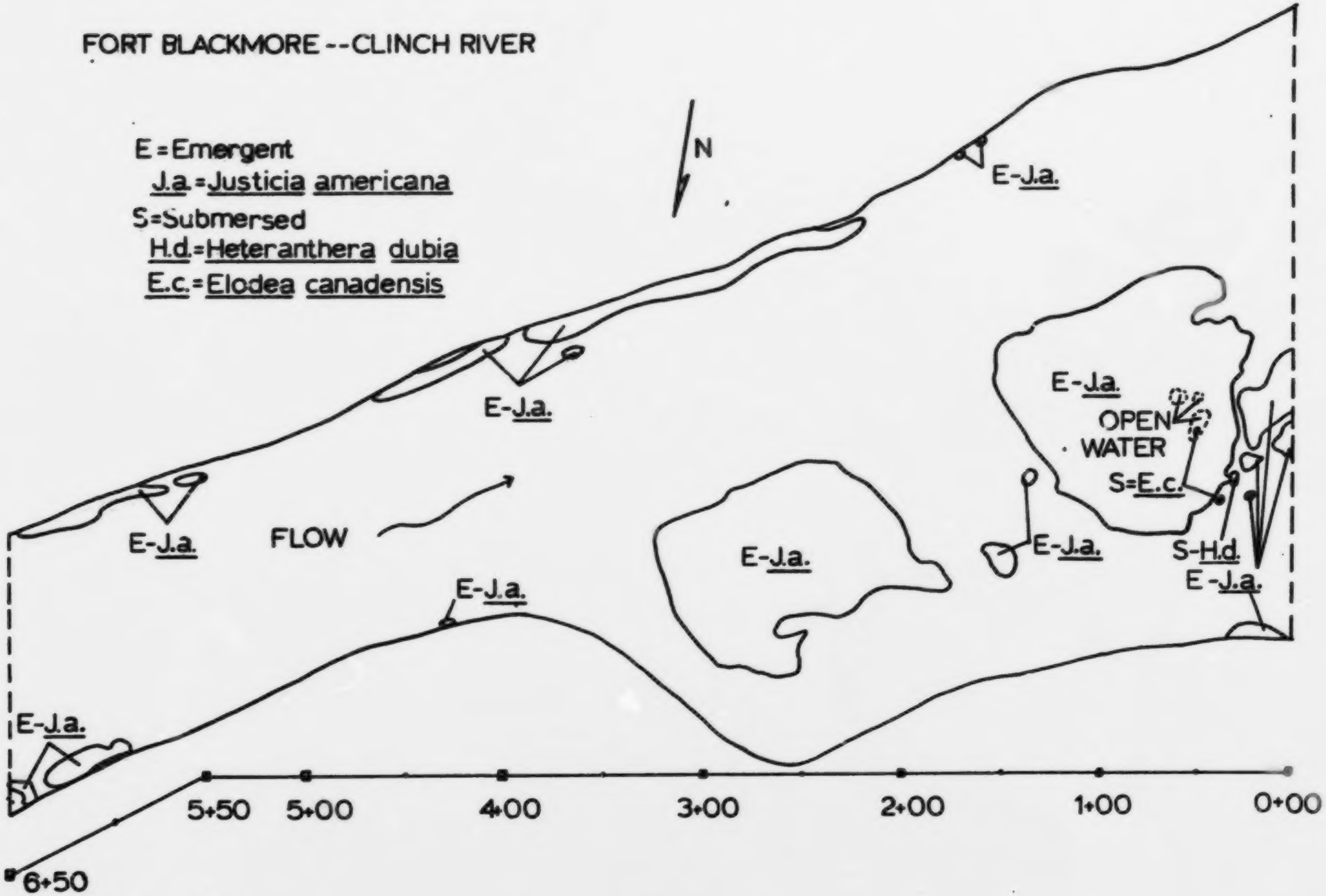

Figure 8. Aquatic Macrophyte Communities at Fort Blackmore - Clinch River, Cumberlandian Mollusk Conservation Program.

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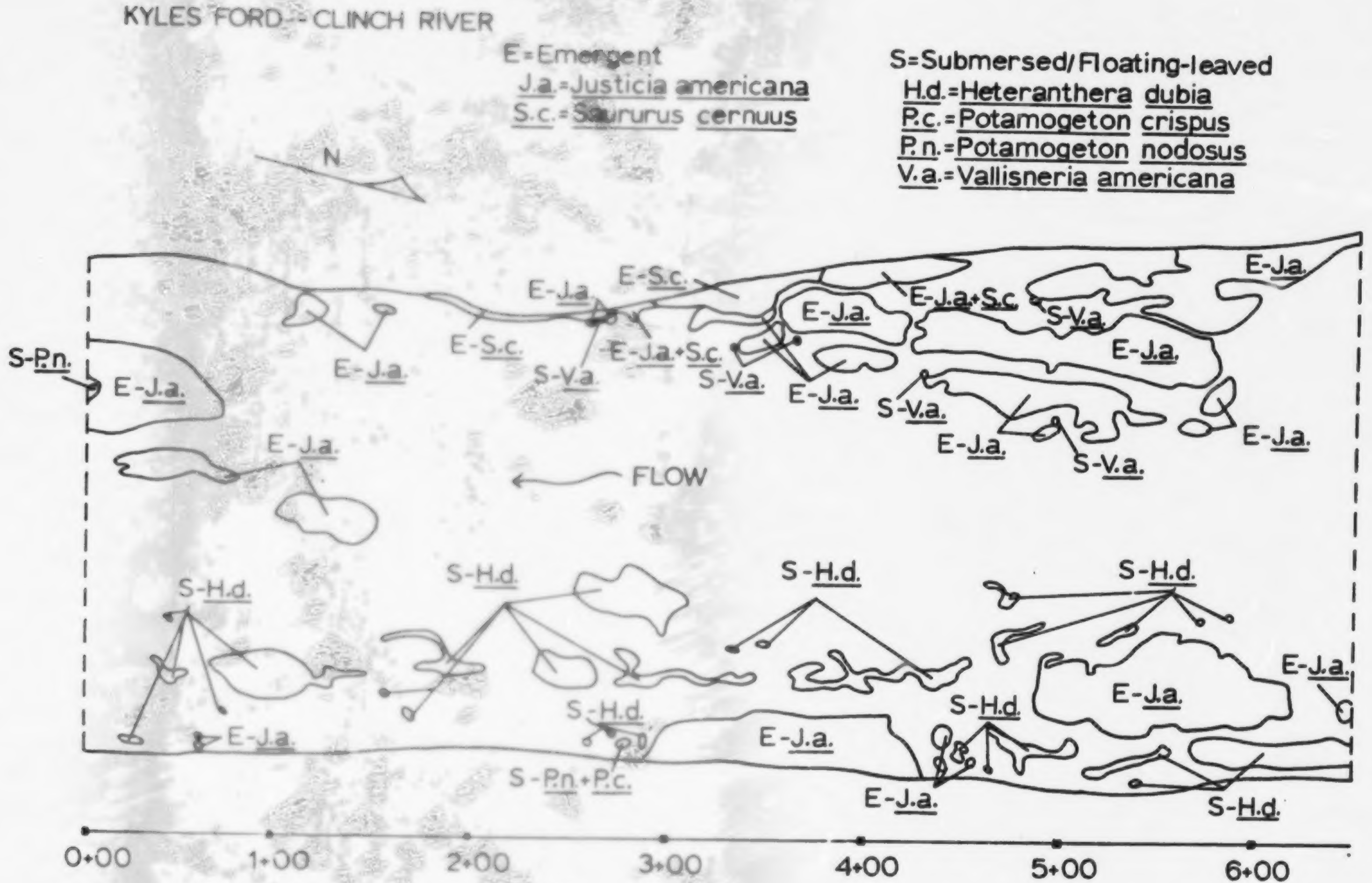

Figure 9. Aquatic Macrophyte Communities at Kyles Ford - Clinch River, Cumberlandian Mollusk Conservation Program.

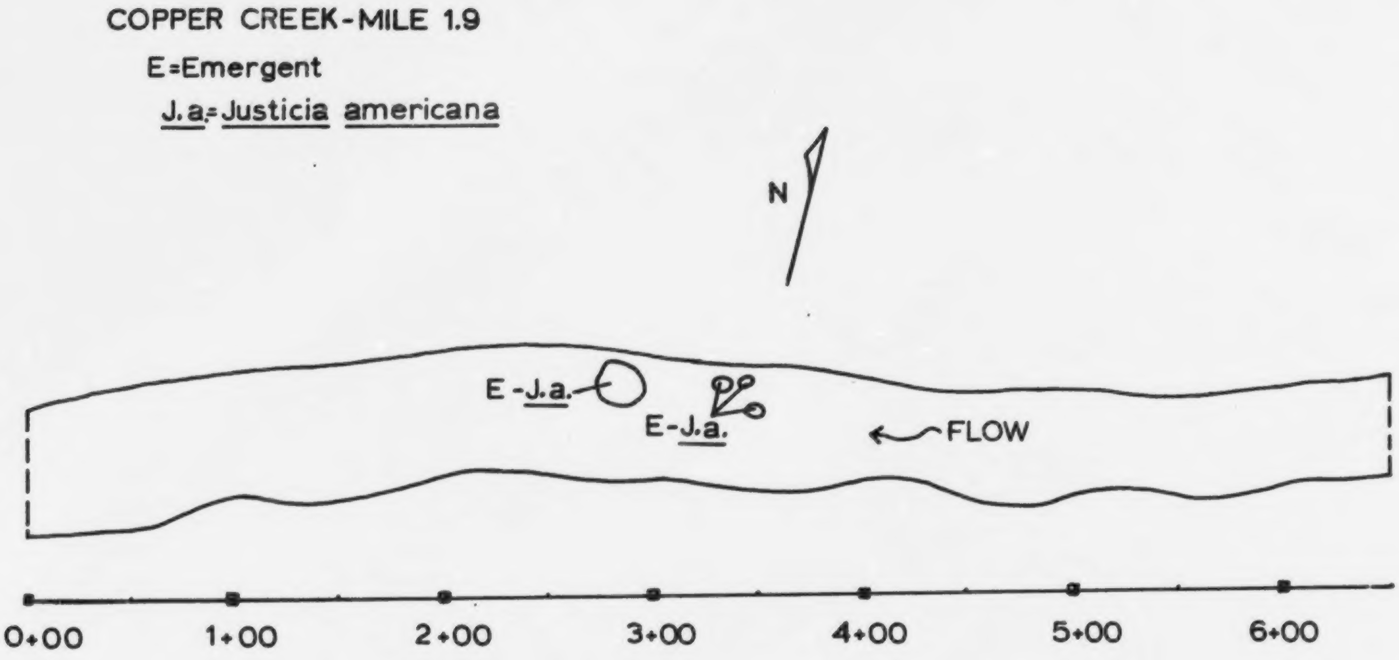

Figure 10. Aquatic Macrophyte Communities at Mile 1.9 - Copper Creek, Cumberlandian Mollusk Conservation Program.

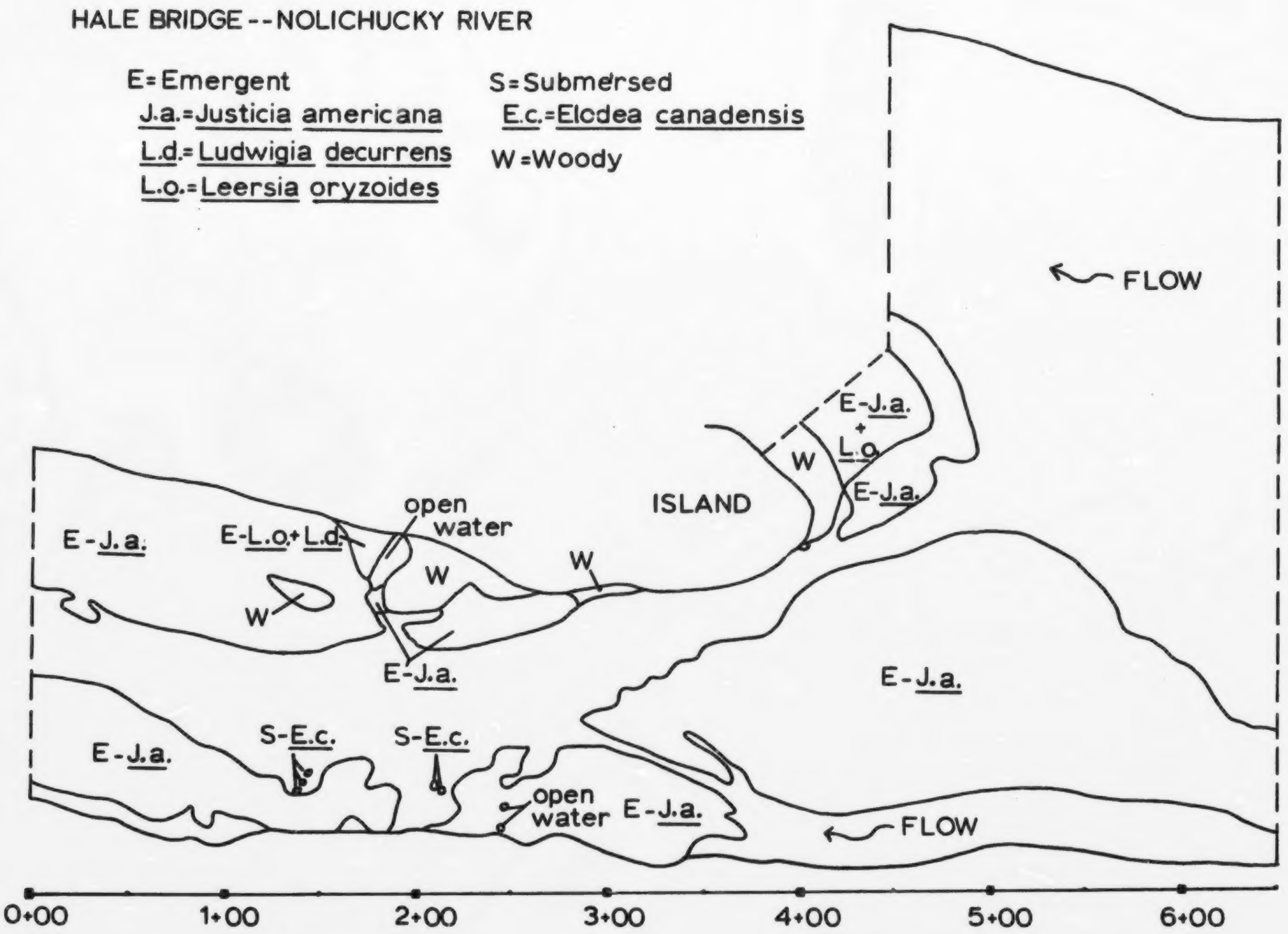

Figure 11. Aquatic Macrophyte Communities at Hale Bridge - Nolichucky River, Cumberlandian Mollusk Conservation Program.

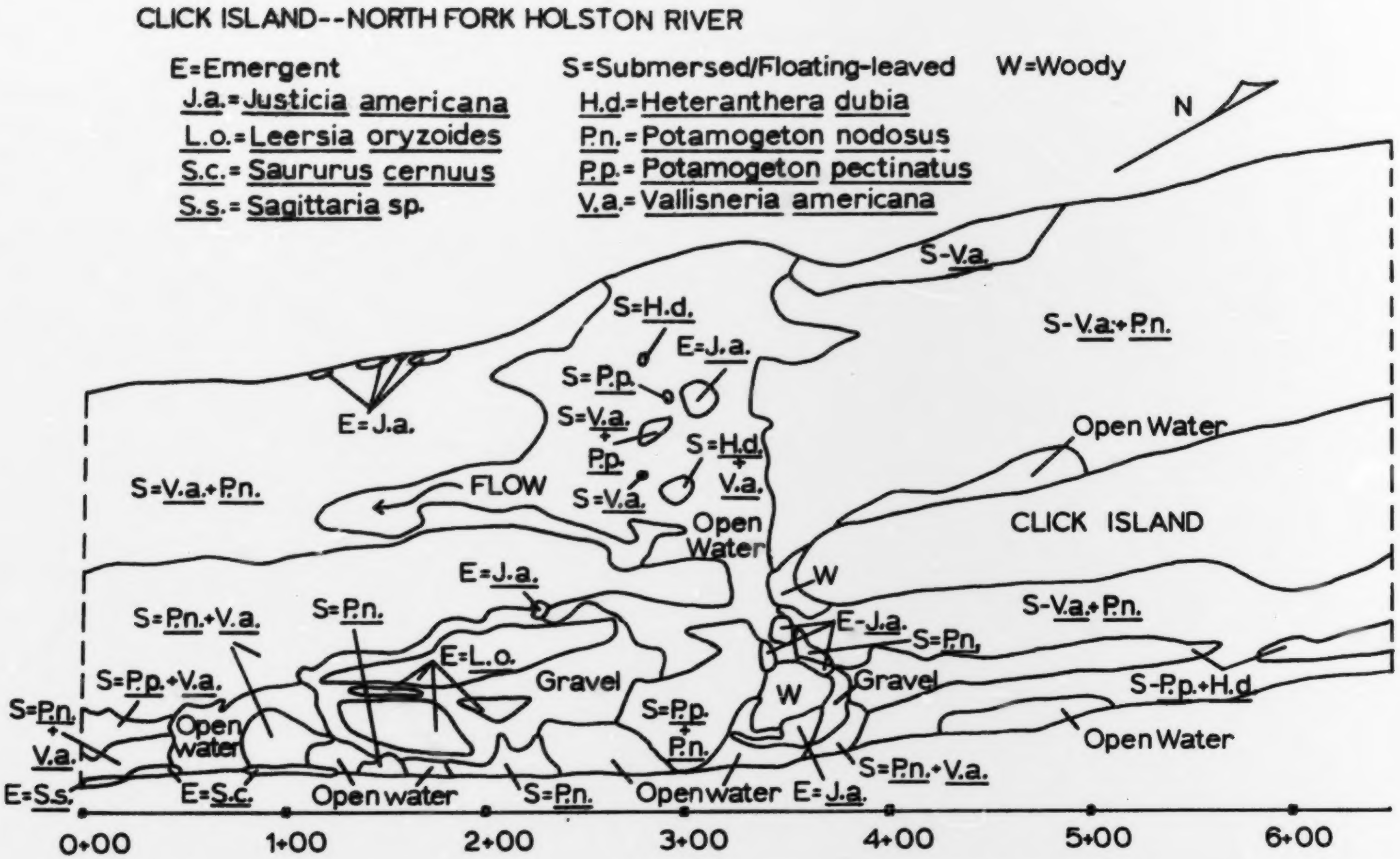

Figure 12. Aquatic Macrophyte Communities at Click Island - North Fork Holston River, Cumberlandian Mollusk Conservation Program.

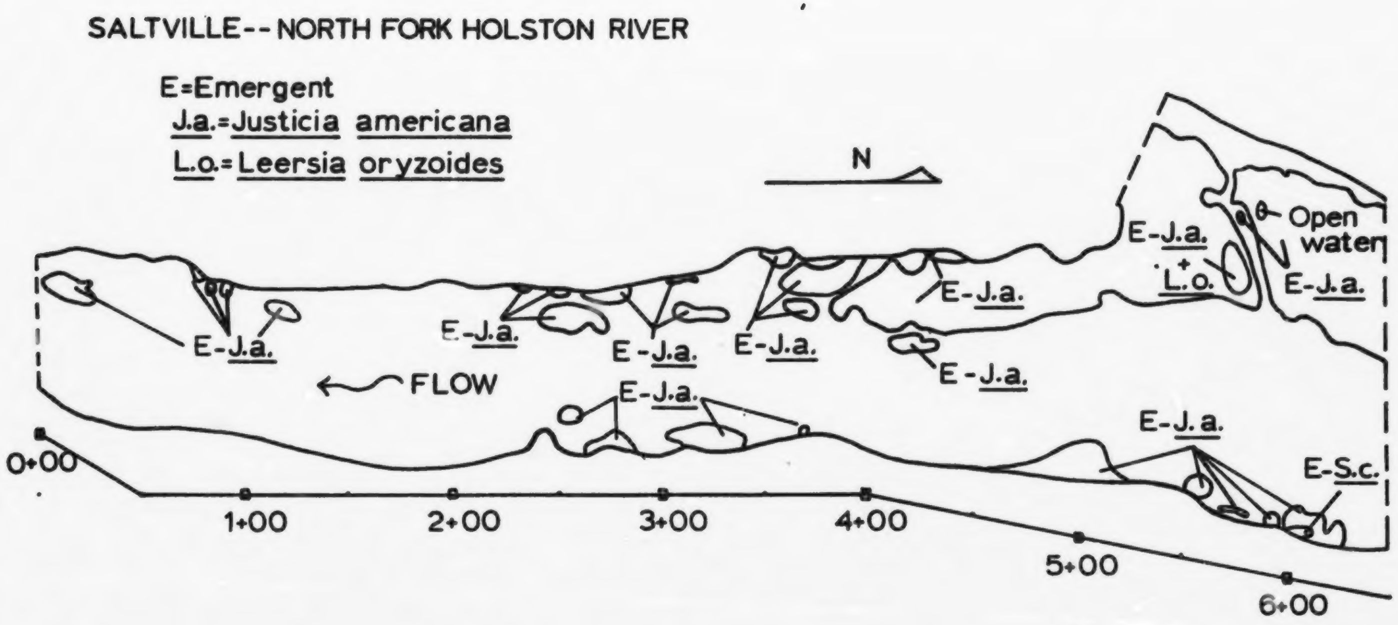

Figure 13. Aquatic Macrophyte Communities at Saltville - North Fork Holston River, Cumberlandian Mollusk Conservation Program.

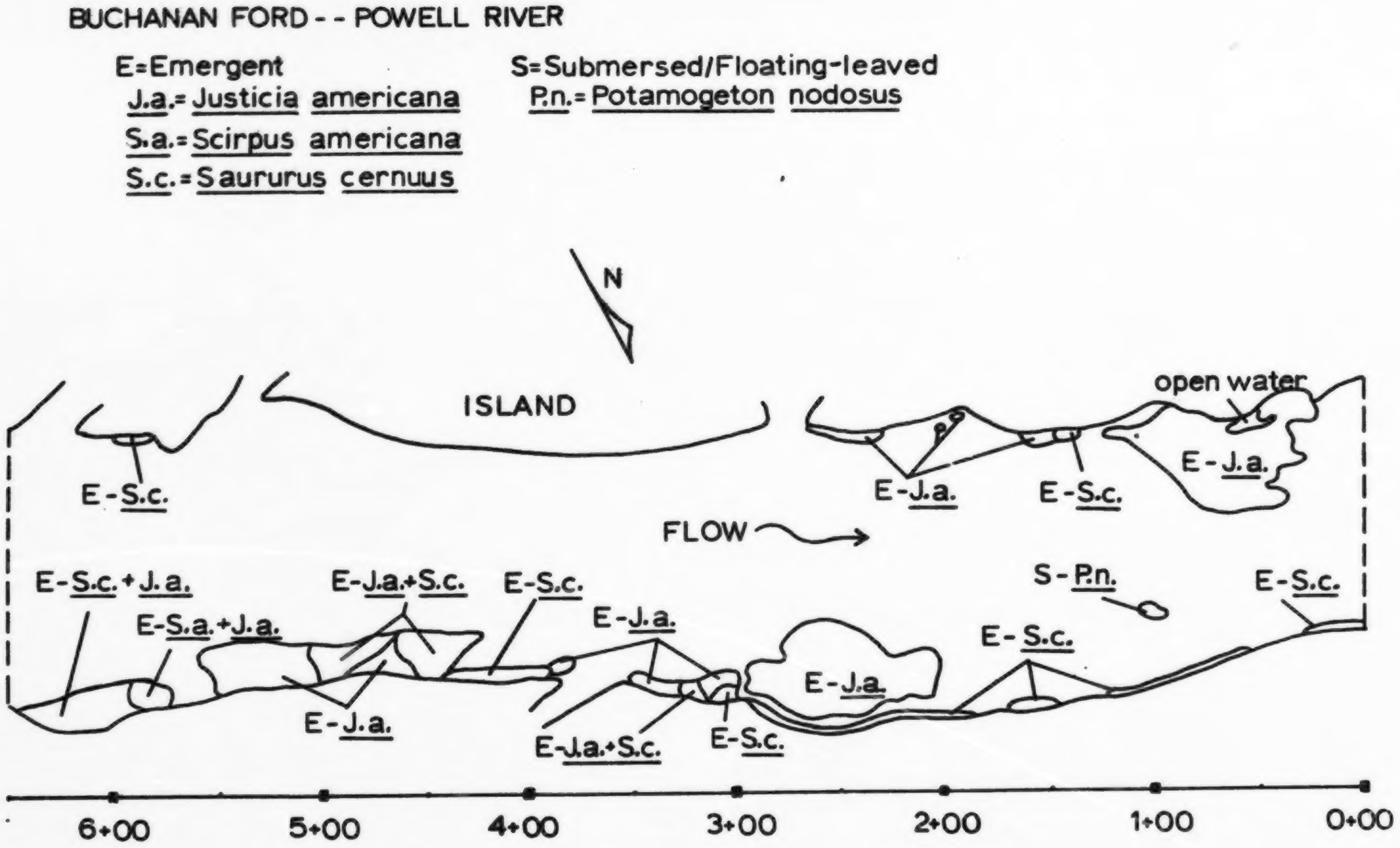

Figure 14. Aquatic Macrophyte Communities at Buchanan Ford - Powell River, Cumberlandian Mollusk Conservation Program.

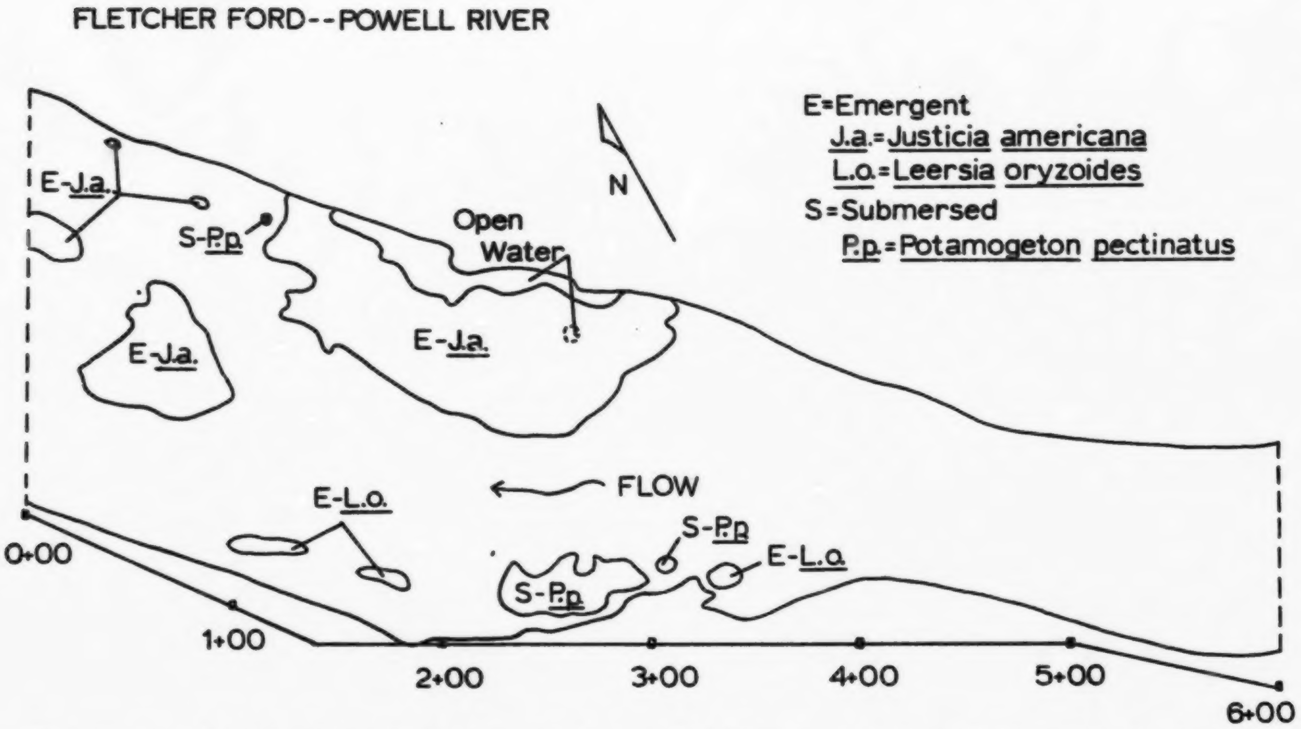

Figure 15. Aquatic Macrophyte Communities at Fletcher Ford - Powell River, Cumberlandian Mollusk Conservation Program.

Table 3. Percentage of Reaches Colonized by Emergent, Submersed/Floating-Leaved, and Composite Vegetation, Cumberlandian Mollusk Conservation Program.

Emergent		Submersed/Floating-Leaved		Composite*	
Site	%	Site	%	Site	%
Nolichucky River - Hale Bridge	42.0	North Fork Holston River - Click Island	43.2	North Fork Holston River - Click Island	47.7
Paint Rock River - Mile 60	23.1	Duck River - Lillards Mill	9.7	Nolichucky River - Hale Bridge	44.0
North Fork Holston River - Saltville	23.0	Duck River - Sowell Ford	6.0	Paint Rock River - Mile 60	28.6
Clinch River - Fort Blackmore	19.3	Paint Rock River - Mile 60	2.4	North Fork Holston River - Saltville	23.0
Powell River - Fletcher Ford	16.4	Buffalo River - Topsy Bridge	2.2	Duck River - Lillards Mill	21.8
Clinch River - Kyles Ford	15.1	Clinch River - Kyles Ford	0.9	Clinch River - Fort Blackmore	19.3
Powell River - Buchanan Ford	12.9	Powell River - Fletcher Ford	0.8	Powell River - Fletcher Ford	17.2
Duck River - Halls Mill	10.6	Duck River - Halls Mill	0.7	Clinch River - Kyles Ford	16.0
Duck River - Lillards Mill	10.4	Powell River - Buchanan Ford	0.1	Powell River - Buchanan Ford	13.0
Duck River - Sowell Ford	5.5	Clinch River - Fort Blackmore	<0.1	Duck River - Halls Mill	12.4
North Fork Holston River - Click Island	3.6	Nolichucky River - Hale Bridge	<0.1	Duck River - Sowell Ford	11.7
Duck River - Dement Bridge	1.4	Copper Creek - Mile 1.9	-	Duck River - Dement Bridge	3.2
Copper Creek - Mile 1.9	1.3	North Fork Holston River - Saltville	-	Buffalo River - Topsy Bridge	2.5
Elk River - Mile 91.4	1.0	Duck River - Dement Bridge	-	Copper Creek - Mile 1.9	1.3
Buffalo River - Topsy Bridge	0.3	Elk River - Mile 91.4	-	Elk River - Mile 91.4	1.0

*Composite = summed % of emergent, submersed/floating-leaved, and woody vegetation.

sites was considered to be of relatively minimal importance due to its small percentage or absence from several sites and no ranking based on this growth form was compiled. In an effort to consider all growth forms at a study reach, the percentages were summed and are shown in table 3. This comparison is perhaps more valid than the preceding two in that it incorporates all growth forms. Eleven of the fifteen study reaches had more than 10-percent vegetative cover with only the Dement Bridge, Buffalo River, Copper Creek, and Elk River study reaches having less than 10-percent coverage. Two sites, Click Island and Hale Bridge, had substantially more total coverage than the other study reaches.

Community Structure

The cluster analysis using submersed/floating-leaved and emergent macrophyte taxa along river reaches is shown in figure 16. Three major clusters (e.g., A, B, C) can readily be discerned with cluster A and B being divisable into a series of smaller clusters (e.g., A_1, A_2, A_3, B_1, B_2). Clusters A and B for the most part correspond to the physiographic provinces described by Fenneman (1938). All the river reaches in cluster B are in the Ridge and Valley Province, while all river reaches in cluster A, except for Copper Creek, are in the Interior Low Plateau Province. Copper Creek, a small tributary of the Clinch River, is in the Ridge and Valley Province. The Interior Low Plateau is generally divided into sections with all the river reaches along the Duck River included in the Nashville Basin section and the reaches along the Elk, Buffalo, and Paint Rock Rivers included in the Highland Rim section.

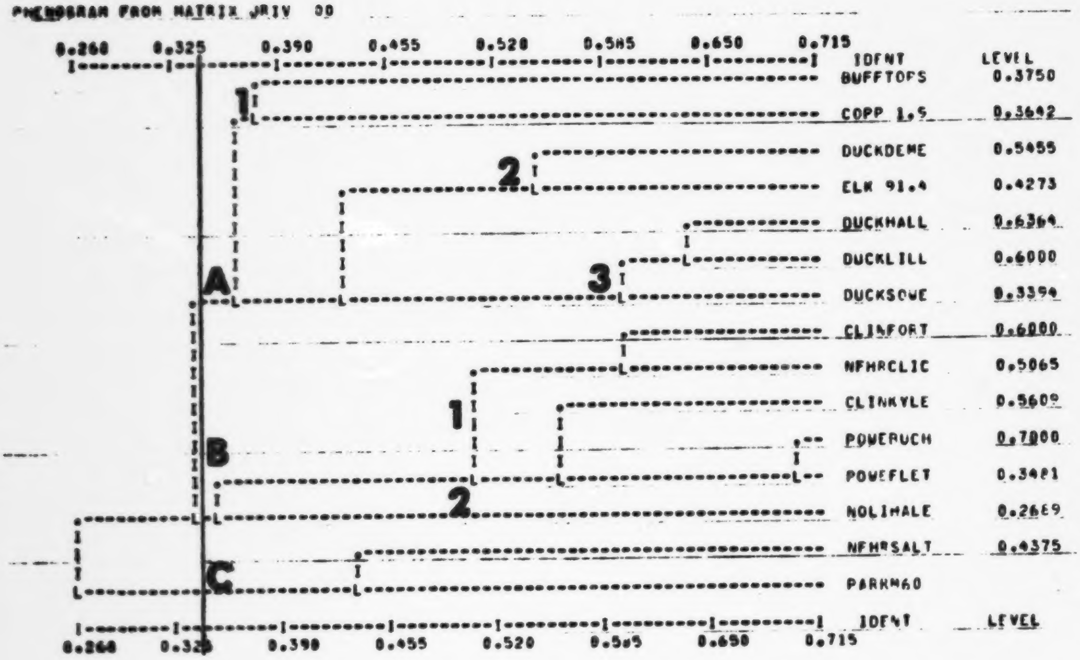

Figure 16. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Submersed/Floating-Leaved and Emergent Taxa along River Reaches, Cumberlandian Mollusk Conservation Program.

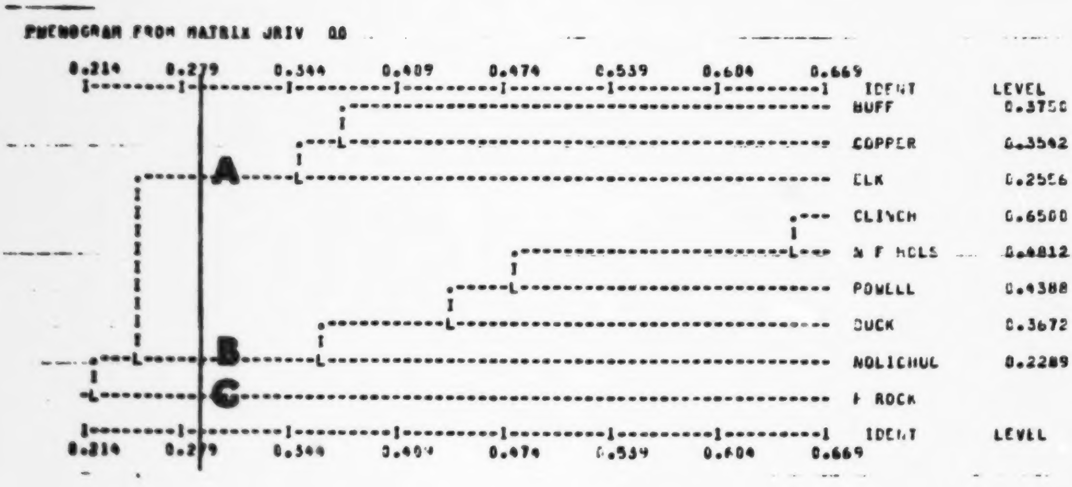

Figure 17. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Submersed/Floating-Leaved and Emergent Taxa along River Systems, Cumberlandian Mollusk Conservation Program.

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Cluster C contains two river reaches, Paint Rock River and North Fork Holston River - Saltville, and has a low (0.2689) level of similarity with clusters A and B. Physiographically, the Saltville study reach belongs with cluster B and the Paint Rock river reach with cluster A. The anomaly in the grouping of cluster C can perhaps be attributed to the headwater characteristics of the North Fork of the Holston above Saltville and the several taxa (e.g., *Potamogeton amplifolius*, *P. crispus*, *Myriophyllum heterophyllum*, *Nuphar luteum*, and *Chara* sp.) that are unique to the Paint Rock River.

Within cluster A, three of the river reaches (A_3) along the Duck River (e.g., Halls Mill, Lillards Mill, and Sowell Ford) had a similarity level of $\geq$.6000 which is high in comparison to most other river reaches. The uppermost river reach (A_2) of the Duck River (Dement Bridge) clustered with the Elk River locality at a 0.5455 similarity level, while the Buffalo River reaches (A_1) and Copper Creek clustered at a low similarity level (0.3750).

In cluster B, five reaches (B_1) along the Clinch, Powell, and North Fork of the Holston River had a level of similarity exceeding 0.5000. The highest similarity level (0.7000) among river reaches was found at the two river reaches of the Powell River. Although included in cluster B, the Nolichucky River reach (B_2) had a low similarity level (0.3481) in comparison with other river reaches in cluster B. This perhaps is attributable to the origin of its headwaters in the mountainous Blue Ridge Province of extreme eastern Tennessee and western North Carolina.

The cluster analysis of the river systems (figure 17) using submersed/floating-leaved and emergent taxa (tables 4 and 5) showed three

Table 4. Submersed/Floating-Leaved Vascular Plants, Bryophytes, and Macroscopic Algae Along River Systems Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program.

	Macrophyte Species																	
	Vascular Plants - Submersed/Floating - Leaved												Bryophytes				Macroscopic Algae	
River System	Callitriche heterophylla	Ceratophyllum demersum	Elodea canadensis	Heteranthera dubia	Myriophyllum heterophyllum	Podostemum ceratophyllum	Potamogeton amplifolius	Potamogeton crispus	Potamogeton foliosus	Potamogeton nodosus	Potamogeton pectinatus	Vallisneria americana	Eurhynchium riparioides	Fissidens fontanus	Leptodictyum riparium	Porella pinnata	Chara sp.	Lemanea sp.
Buffalo River						X						X				X		
Paint Rock River					X		X	X	X						X	X	X	
Duck River			X	X		X			X	X				X	X	X		
Elk River	X					X								X		X		
Clinch River			X	X						X	X	X			X	X		X
Copper Creek																X		
Nolichucky River			X			X							X	X		X		X
North Fork Holston River		X	X	X					X	X	X	X			X	X	X	
Powell River										X	X					X		X

Table 5. Emergent Macrophytes Along River Systems Being Investigated for Mollusk Transplants, Cumberlandian Mollusk Conservation Program.

River System	*Decodon verticillata*	*Eleocharis palustris*	*Heteranthera reniformis*	*Iris pseudo-acorus*	*Justicia americana*	*Leersia oryzoides*	*Nasturtium officinale*	*Nuphar luteum*	*Onoclea sensibilis*	*Orontium aquaticum*	*Phalaris arundianacea*	*Sagittaria* sp.	*Saururus cernuus*	*Scirpus americanus*	*Scirpus validus*
Buffalo River					X	X			X	X			X		
Paint Rock River					X	X		X							X
Duck River	X				X	X	X						X	X	
Elk River			X		X	X	X								
Clinch River		X			X	X					X		X	X	X
Copper Creek					X	X									
Nolichucky River		X			X	X			X					X	X
North Fork Holston River		X		X	X	X						X	X	X	X
Powell River		X			X	X	X						X	X	

major groupings with (1) cluster A consisting of the Buffalo River, Copper Creek, and the Elk River; (2) cluster B of the Clinch, North Fork of the Holston, Powell, Duck, and Nolichucky Rivers; and (3) cluster C comprised of only the Paint Rock River. A relatively high level of similarity between river systems occurs in cluster B with the Clinch, North Fork of the Holston, Powell, and Duck Rivers all having a similarity level exceeding 0.4000. The highest similarity (0.6500) between individual river systems is Clinch and North Fork of the Holston River. The river systems in cluster A were rather loosely grouped with the highest similarity being 0.3750. Cluster C, consisting of only the Paint Rock River, had a very low level of similarity (0.2289) with the other two clusters.

PLANKTON, ORGANIC SOLIDS, AND PERIPHYTON

Nutritional requirements of freshwater mussels consist entirely of microscopic organisms (plankton) and organic debris floating in the water and are met by the mussel's ability to extract these particles. The latter is accomplished through filtering action of the gills which, with assistance of secreted mucus and numerous cilia, capture particles from water directed through the mussel's incurrent siphon at rates of up to 24 ml per minute or 35 liters per day (Allen, 1914). Surfaces of the gills and the upper part of the mantle and contiguous faces of the labial palps direct trapped food entangled in stringlike masses of mucus to the mouth. The lower part of the mantle, which collects heavier and/or rejected particles, functions to remove undesirable matter from the mussel (Hickman, 1967).

Allen (1914) investigated gut contents of freshwater mussels and found them different from their marine counterparts in two aspects: (1) freshwater mussels contain a higher proportion of animal food and (2) plant material is not dominated by diatoms (Chrysophyta), but is at least equally composed of other algal forms. A list of genera observed in mussel gut contents is provided in table 6. Allen (1914) also suggests that periphyton may play a role in mussel nutrition, especially when it is attached to the posterior part of the shell protruding above the substratum.

The following results contrast study reaches based first on abundance of potential food organisms and second on taxonomic association (i.e., community structure) measured over a period of months. Each community is analyzed separately in an overall attempt to specify ecologically similar study reaches with sufficient nutritional content for supporting *Conradilla caelata* and other pelecypod species.

Phytoplankton

Abundance--Total phytoplankton abundance data (appendix C) for surface and near bottom depths during 1980 and 1981 are illustrated in figures 18 through 21. These figures show similar trends for both surface and near-bottom depths; in fact, test results (table 7) show no significant differences existed between depths at each site for 1980 and 1981.

In 1980, phytoplankton abundance was greatest at Duck River Mile 243.1 (Dement Bridge). This likely reflects discharges from Normandy Reservoir which is rich in plankton and is located 8.8 kilometers (5.5 miles) upstream. Other reaches with appreciable phytoplankton were Clinch River Mile 227.4 (Fort Blackmore), Duck River Mile 179.1 (Lillards Mill),

Table 6. Algae Genera Found in Mussel Gut Contents (After Allen, 1914)

Chrysophyta	Chlorophyta	Cyanophyta
Amphora	*Coelastrum*	*Anabena*
Arachnoidiscus	*Cylindrocapsa*	*Aphanocapsa*
Cocconeis	*Eudorina*	*Leptothrix*
Cocconema	*Gloeocystis*	*Lyngbyia*
Coscinodiscus	*Oedogonium*	*Merismopedia*
Craspedodiscus	*Pandorina*	*Oscillatoria*
Cymbella	*Pediastrum*	
Epithemia	*Protococcus*	
Fragilaria	*Scenedesmus*	
Gomphonema	*Spirogyra*	
Melosira	*Tetraspora*	
Navicula	*Ulothrix*	
Pleurosigma	*Vaucheria*	
Surirella		
Synedra		
Triceratium		

CMCP 1980

TOTAL PHYTOPLANKTON DEPTH-NS

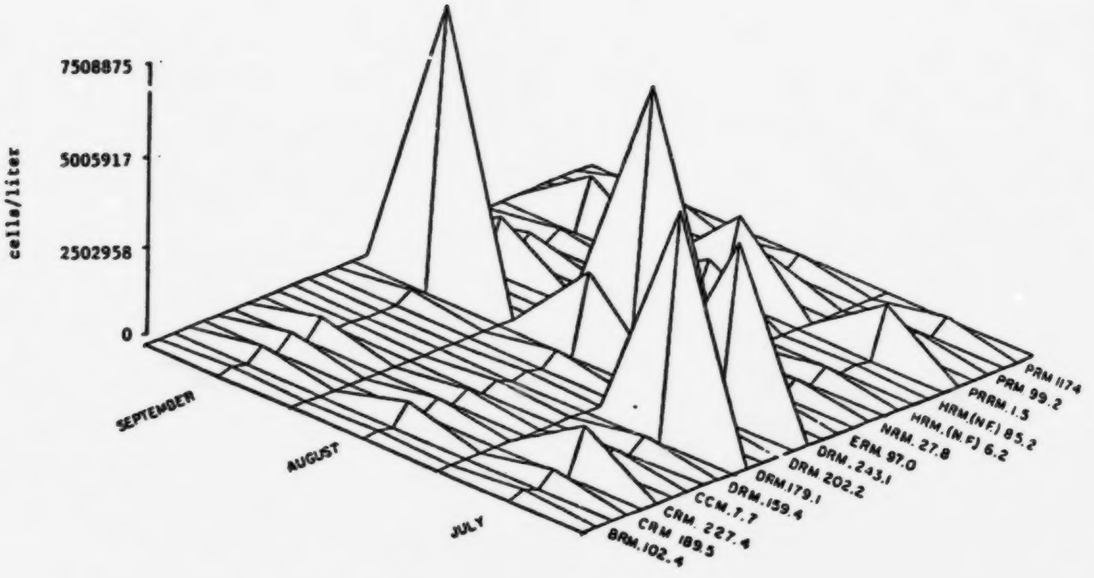
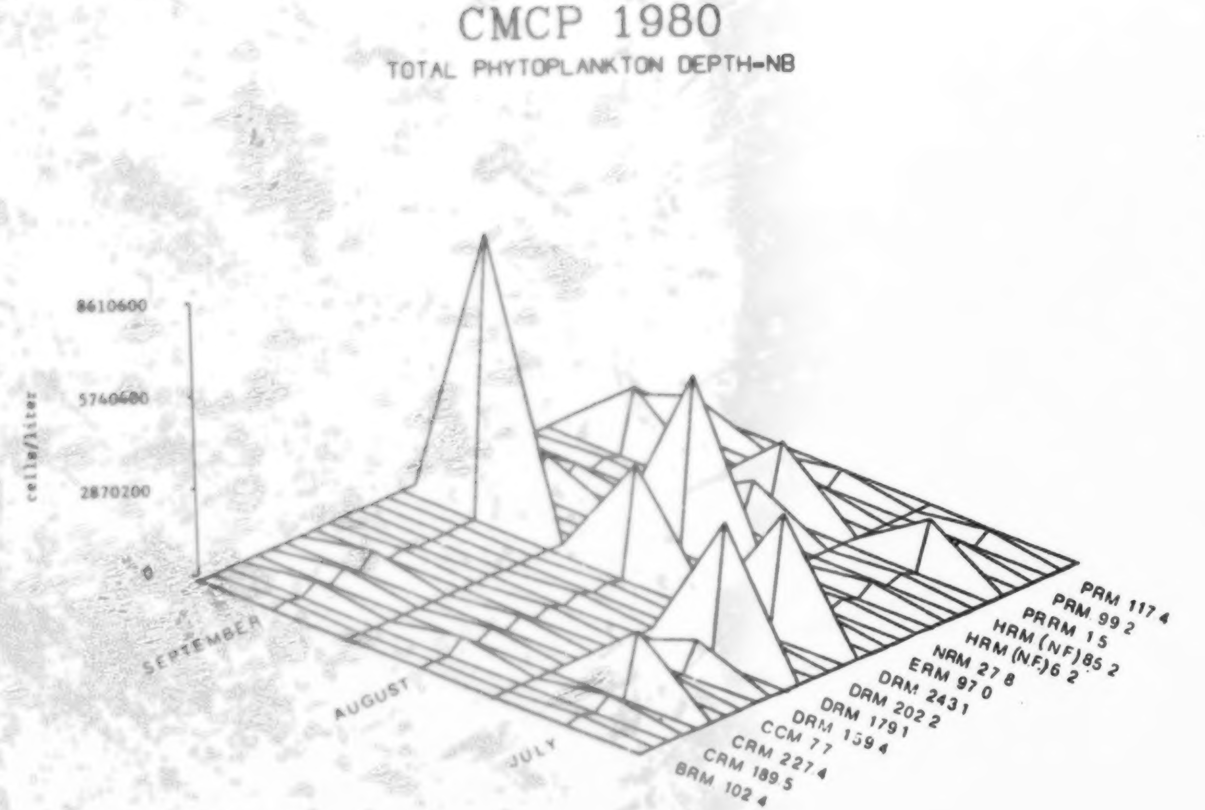


Figure 18. Monthly Phytoplankton Abundance at the Near-Surface Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980.



CMCP 1980

TOTAL PHYTOPLANKTON DEPTH-NB

Figure 19. Monthly Phytoplankton Abundance at the Near-Bottom Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980.

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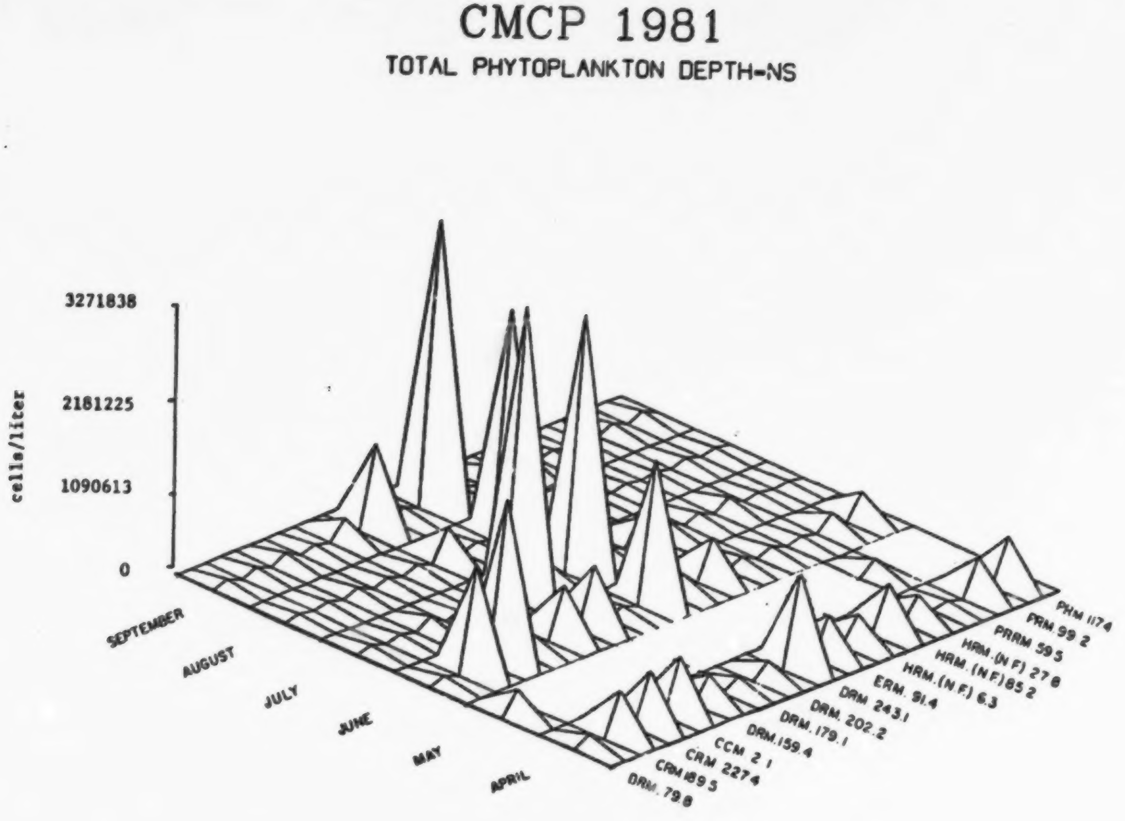

CMCP 1981

TOTAL PHYTOPLANKTON DEPTH-NS

Figure 20. Monthly Phytoplankton Abundance at the Near-Surface Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981.

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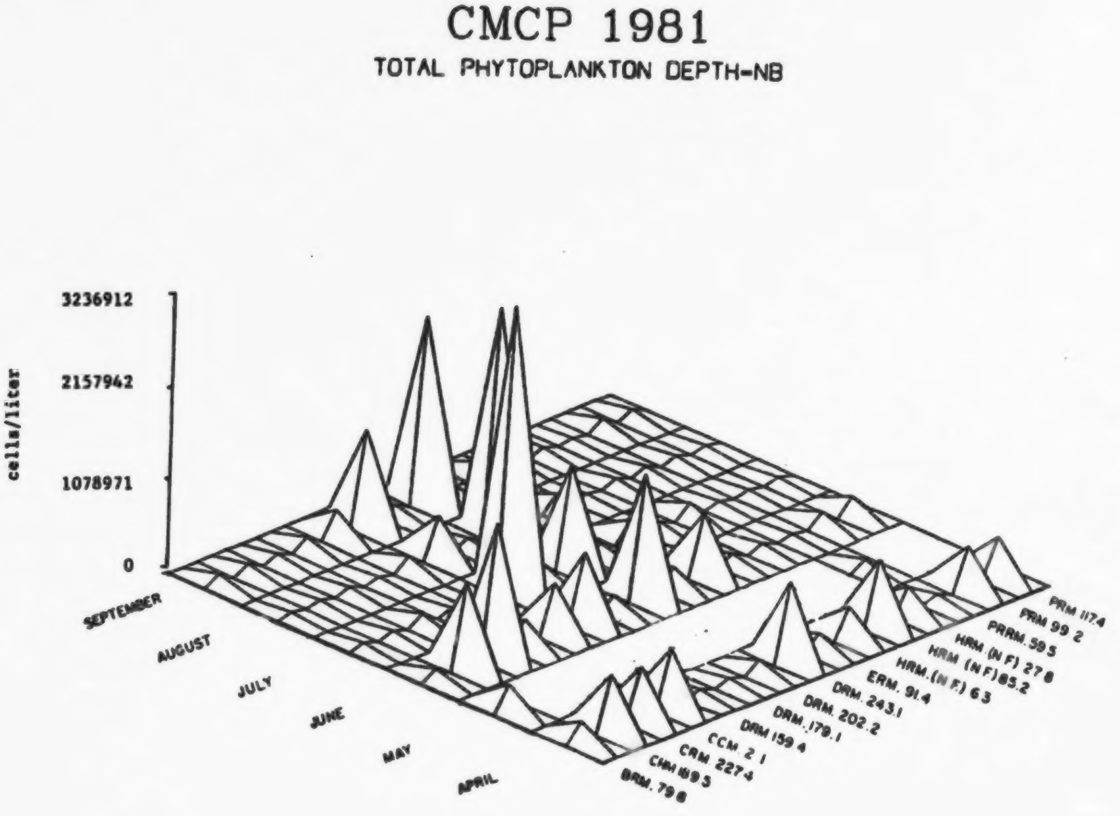

Figure 21. Monthly Phytoplankton Abundance at the Near-Bottom Depth of Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981.

Table 7. T-Test for Depth (Surface and Near Bottom) Differences of Phytoplankton at Each Designated Study Reach, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

		Degrees of Freedom*		t-Value†	
	Study Reach	1980	1981	1980	1981
1.	Buffalo River				
	Metal Ford	10		0.688	
	Topsy Bridge		22		1.021
2.	Paint Rock River				
	Estill Fork	10		0.642	
	Mile 60.0		22		0.477
3.	Duck River				
	Lillards Mill	6	18	0.390	0.104
4.	Duck River				
	Sowell Ford	10	14	0.841	0.183
5.	Duck River				
	Halls Mill	10	18	1.317	0.752
6.	Duck River				
	Dement Bridge	10	18	0.258	1.836
7.	Elk River				
	Chennault Ford	6		1.010	
	Mile 91.4		14		0.715
8.	Clinch River				
	Fort Blackmore	10	18	0.458	0.233
9.	Clinch River				
	Kyles Ford	10	18	1.294	0.057
10.	Copper Creek				
	Mile 7.7	10		0.443	
	Mile 1.9		18		0.441
11.	Nolichucky River				
	Hale Bridge	10	18	0.298	0.383
12.	Holston River (N.F.)				
	Click Island	10	18	2.148	0.183
13.	Holston River (N.F.)				
	Saltville	10	18	0.064	0.774

(Continued)

Table 7. (Continued)

	Study Reach	Degrees of Freedom*		t-Value†	
		1980	1981	1980	1981
14.	Powell River Buchanan Ford	10	17	0.951	0.333
15.	Powell River Fletcher Ford	10	18	0.830	0.339

*df = $n_1 + n_2 - 2$

†t-statistic for small sample tests of differences between two means; $\mu_1 = \mu_2$ (Freund, 1973)

Critical values of t-distribution:

$t_{.05[6]} = 2.447$	$t_{.05[17]} = 2.110$
$t_{.05[10]} = 2.228$	$t_{.05[18]} = 2.101$
$t_{.05[14]} = 2.145$	$t_{.05[22]} = 2.074$

Nolichucky River Mile 27.8 (Hale Bridge), North Fork Holston River Mile 85.2 (Saltville), Paint Rock River (Estill Fork Mile 1.5), and Powell River Mile 117.4 (Fletcher Ford).

In 1981, phytoplankton was most numerous June through September. Again, greatest abundance occurred downstream of Normandy Reservoir on the Duck River at Dement Bridge (mile 243.1). Other areas with appreciable phytoplankton throughout the year included Duck River Miles 159.4 and 179.1 (Sowell Ford and Lillards Mill). Several other reaches which demonstrated early (April through June) phytoplankton abundance were Clinch River Miles 189.5 and 227.4 (Kyles Ford and Fort Blackmore), North Fork Holston River Mile 6.3 (Click Island), and Powell River Miles 99.2 and 117.4 (Buchanan and Fletcher Fords).

Locations with the most (yearly mean values) phytoplankton in both 1980 and 1981 were Dement Bridge (5.0 million and 2.0 million cells/liter) and Lillards Mill (2.6 million and 1.1 million cells/ liter). Hale Bridge also demonstrated large phytoplankton abundance (2.4 million cells/liter) in 1980, but was much less productive in 1981 (0.3 million cells/liter). All three areas have an extensive upstream pool which provides sufficient retention for developing phytoplankton communities. Duck River locations also have a high potential for algal development because of naturally high phosphorus levels (TVA, 1981).

A statistical treatment of study reaches based on abundance data for total phytoplankton and major groups (Chrysophyta, Chlorophyta, and Cyanophyta) is summarized in table 8. Highly significant location differences were recorded for each one-way ANOVA. Several trends are indicated among those reaches with greatest abundance of phytoplankton. Dement Bridge, Lillards Mill, Hale Bridge, and Fort Blackmore (reaches 6, 3, 11,

Table 8. Phytoplankton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Year	Phytoplankton Group	Degrees of Freedom (Treatment, Error)	F-Value	P >F	Statistically Similar Reaches (α = 0.05)* Lowest														Highest	R^2
1980	Total	(14, 157)	16.34	0.0001	1	5	4	7	13	10	12	14	9	15	8	3	11	2	6	0.593
	Chrysophyta	(14, 157)	10.22	0.0001	5	4	1	6	3	13	9	15	2	14	11	7	10	12	8	0.477
	Chlorophyta	(14, 157)	6.19	0.0001	12	10	1	5	6	7	13	4	2	8	9	14	15	3	11	0.356
	Cyanophyta	(14, 157)	7.45	0.0001	14	7	13	15	8	1	10	12	4	9	5	11	3	2	6	0.399
1981	Total	(14, 276)	19.33	0.0001	2	1	13	15	5	12	14	7	10	9	4	8	11	3	6	0.495
	Chrysophyta	(14, 276)	3.27	0.0001	2	5	13	4	1	3	7	14	15	12	9	11	10	6	8	0.142
	Chlorophyta	(14, 276)	8.57	0.0001	2	10	12	1	15	13	14	7	9	8	5	4	6	11	3	0.303
	Cyanophyta	(14, 276)	16.45	0.0001	12	1	2	1	15	10	13	9	8	7	5	11	4	3	6	0.455

Table 8. Continued

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*All reaches underscored by the same line are similar. Rankings are based on log transformed data.

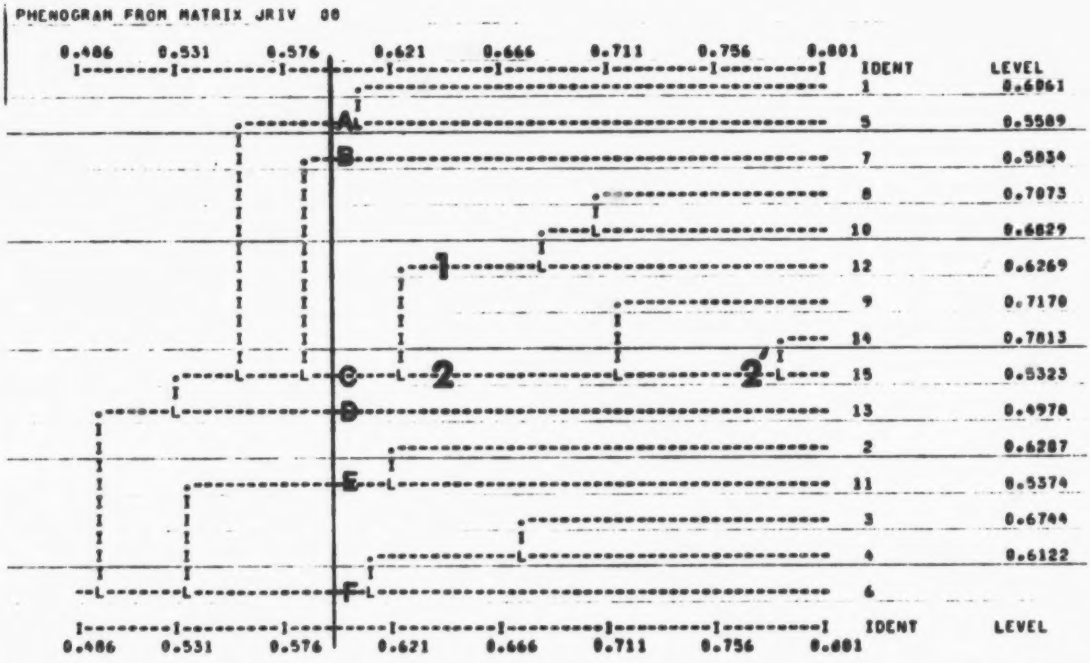
Reaches:
1. Buffalo River; Metal Ford (1980), Topsy Bridge (1981)
2. Paint Rock River; Estill Fork (1980), Mile 60 (1981)
3. Duck River, Lillards Mill
4. Duck River, Sowell Ford
5. Duck River, Halls Mill
6. Duck River, Dement Bridge
7. Elk River; Chennault Ford (1980); Mile 91.4 (1981)
8. Clinch River, Fort Blackmore
9. Clinch River, Kyles Ford
10. Copper Creek; Mile 7.7 (1980), Mile 1.9 (1981)
11. Nolichucky River, Hale Bridge
12. North Fork Holston River, Click Island
13. North Fork Holston River, Saltville
14. Powell River, Buchanan Ford
15. Powell River, Fletcher Ford

and 8) consistently (both years) demonstrated increased total abundance. Dement Bridge was statistically highest and separate from other locations in 1980 and 1981. Lillards Mill was second in abundance and separate from all other reaches in 1981, but grouped with Estill Fork (discontinued in 1981) and Hale Bridge in 1980. In 1981, Kyles Ford and Sowell Ford (reaches 9 and 4) were similar to Hale Bridge and Fort Blackmore (sites 11 and 8), forming the third most productive set of study reaches based on total phytoplankton. Below two (1980) and three (1981) levels of ranking, much overlapping by location occurred so that no obvious differentiation could be made. Therefore, Kyles Ford, Sowell Ford, Fort Blackmore, Hale Bridge, Lillards Mill, and Dement Bridge are best suited for total plankton production, listed in increasing order of phytoplankton abundance.

By comparing individual group (taxonomic level-division) and total phytoplankton statistical rankings, dominant units of study reach similarity became obvious. Empirical data are provided in appendix D. At Lillards Mill (reach 3) Chlorophyta was the dominant group while Cyanophyta was also a major contributor, especially in 1981. In terms of chlorophyte abundance, Lillards Mill, Hale Bridge, and Sowell Ford were consistently similar (1980 and 1981). In terms of cyanophyte abundance, Lillards Mill and Dement Bridge were similar in 1980. In 1981, Lillards Mill and Sowell Ford, with a secondary group of Hale Bridge, Halls Mill, Elk River, and Fort Blackmore were similar. Dement Bridge was significantly more productive than all other reaches. Therefore, in terms of overall (total and dominant group) community abundance, most suitable locations were Lillards Mill, Hale Bridge, and Sowell Ford and possibly Halls Mill, Dement Bridge, Elk River, and Fort Blackmore.

Community Structure--Designated study reaches for 1980 were grouped according to taxonomic structure (presence/absence) in a Q-mode cluster shown in figure 22. The 15 study reaches were separated into six primary clusters (e.g., A through F) which contained up to two major subgroupings (e.g., 1, 2; 1', 2'). The largest primary cluster (C) had a level of similarity of 0.6269 and contained six reaches (Fort Blackmore, Copper Creek, Click Island, Kyles Ford, Buchanan Ford, Fletcher Ford), all found in the Ridge and Valley Province (see description in aquatic macrophyte discussion). Within this group, Buchanan Ford and Fletcher Ford on the Powell River (similarity = 0.7813) and Kyles Ford on the Clinch River (0.7170) were most similar (Cluster C_2). Separation of clusters C_2 and C_1 reflects a greater number of phytoplankton taxa in study reaches of cluster C_1 (range = 35-38 taxa) compared with the number of taxa in cluster C_2 (range = 28-31 taxa). This difference in taxa is especially obvious in the phytoplankton group Cyanophyta or blue-green algae. Cluster F (0.6122 level of similarity) consisted of three Duck River reaches: Lillards Mill, Sowell Ford, and Dement Bridge which contained 41, 35, and 47 phytoplankton taxa, respectively. Halls Mill, the other Duck River reach, which grouped with the study reach at Metal Ford on the Buffalo River (cluster A, 0.6061 level), contained only 30 taxa. Study reaches with the greatest number of taxa formed cluster E. These reaches, Estill Fork on the Paint Rock River and Hale Bridge on the Nolichucky River, contained 51 and 59 taxa, respectively. A listing of taxa encountered at each study reach in 1980 is provided in table 9.

A further description of taxonomic differences among study reaches in 1980 is provided in principal component analysis (PCA). Respectively,



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Cumberlandian Mollusk Conservation Program
Study Reaches

1. Buffalo River; mile 102.6, Metal Ford (1980); mile 79.8, Topsy Bridge (1981)
2. Paint Rock River; Estill Fork, mile 1.5 (1980); [illegible] 30.0 (1981)
3. Duck River mile 179.1, Lillards Mill
4. Duck River mile 159.6, Sowell Ford
5. Duck River mile 202.2, Halls Mill
6. Duck River mile 243.1, [illegible] Bridge
7. Elk River; mile 97.0, [illegible] Ford (1980); mile 91.4 (1981)
8. Clinch River mile 227.6, Fort Blackmore
9. Clinch River mile 189.5, Kyles Ford
10. Copper Creek; mile 7.7 (1980); mile 1.9 (1981)
11. Nolichucky River mile 27.8, Hale Bridge
12. North Fork Holston River mile 6.2, [illegible] Island
13. North Fork Holston River mile 83.2, Saltville
14. Powell River mile 99.2, Buchanan Ford
15. Powell River mile [illegible], Fletcher Ford

Figure 22. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Phytoplankton Taxa Collected at Study Reaches, July through September 1980, Cumberlandian Mollusk Conservation Program.

Table 9. Phytoplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHLOROPHYTA															
ACTINASTRUM	1	1	2	1		2	1				3			1	1
ANKISTRODESMUS	1	2	2	2	2	2	2	2	1	1	3	1	2	1	
BOTRYOCOCCUS											2				
BRACTEACOCCUS				1											
CARTERIA		2				1					2				
CHLAMYDOMONAS	1	3	2	3	2	3	2	3	3	2	3	1	2	2	2
CHLORELLA			2	2	2	1	2	3	3	2	2	1	1	1	2
CHLOROGONIUM		1	1	1		1			1		2	1	1		
CHODATELLA					1	2			1		2				
CLOSTERIOPSIS	2	2	1	1	1	2					2		1		
CLOSTERIUM				1		1		1		1					
COELASTRUM		1		1		1					2				
COSMARIUM		2						1	1		1			1	1
CRUCIGENIA	2							1			1		1		
DACTYLOCOCCUS						1									
DICTYOSPHAERIUM			1			2		1			2	1	1		
ELAKATOTHRIX								1			1				
EUDORINA											1		1		
FRANCEIA			1			2									
GOLENKINIA		1	1	1		1	1				1				
GONIUM		1									1		2		
HYALOTHECA													1		
KIRCHNERIELLA			2	1		1	1	1	1	1	2	2	1	1	
MOUGEOTIA		3	1												
OOCYSTIS		1	2		1	1		1		1	2				
PANDORINA		3	1	1											
PEDIASTRUM						1					2		1		
PROTOCOCCUS			1												
PTEROMONAS											1				
PYRAMIMONAS		2		2	1						1	1			1
SCENEDESMUS	2	2	2	3	3	3	2	3	2	2	3	1	3	3	3
SCHROEDERIA	1	1	2	1	1	1		1	1		3	1		1	2
SELENASTRUM	1		1	1											
SPERMATOZOOPSIS	1	1	2	2	2				2		1		1	2	2
SPIROGYRA		2													
SPONDYLOSIUM									1	1					
STAURASTRUM		1				3					1				
STIGEOCLONIUM		1									1		1		
TETRAEDRON						2	1				1	1			
TETRALLANTOS											1				
TETRASTRUM						1									
TREUBARIA			1			1					2				
TROCHISCIA		1													

Table 9. (Continued)

TAXA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	STUDY REACH														
ULOTHRIX		1					1								
CHRYSOPHYTA															
ACHNANTHES	3	3	2	1	1	3	2	2	1	3	3	3	3	3	1
ATTHEVA		1													
CHAETOCEROS											1				
COCCONEIS	3	1	1	3	2		1	3	3	3	2	3	3	3	3
CYCLOTELLA			1	2		1		1	2	1				1	1
CYMATOPLEURA	1														
CYMBELLA	2	2	1	1	2	1	2	3	3	3	2	3	3	3	3
DIATOMA		1					2	3	2	2	3	3	1	2	3
DICHOTOMOCOCCUS			1		1	1									
DINOBRYON		3	1							1			1		
DIPLONEIS														1	
FRAGILARIA		2													
GOMPHONEMA	3	3	1		1	2	2	3	3	3	2	3	3	2	2
GYROSIGMA					1		1	3	2	2	1	3	2	1	
MALLOMONAS		2								1	1				
MELOSIRA	2	1	2	2	2	3	2	3		1	3		2	3	2
NAVICULA	3	3	1	3	3	3	2	3	3	3	3	3	3	3	3
NITZSCHIA	3	1	1	3	1	1	2	3	3	3	3	3	3	3	3
PINNULARIA		1													
RHIZOSOLENIA					1	2									
RHOICOSPHENIA	1				1			2	1	1	1	1		1	2
STEPHANODISCUS	1	1	2	2	1	2	1	3	2	2	3	1		3	3
SURIRELLA	2	2		1	1			3	2	2	1	1	1	1	2
SYNEDRA	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3
CRYPTOPHYTA															
CHROOMONAS		1						1	1	1	2	1	1		
CRYPTOMONAS	3	3	2	3	3	2	2	1	1	1	2	1	1	2	1
HETEROMASTIX		1								1	1	1			
CYANOPHYTA															
ANABAENA		2				2		1							
ANABAENOPSIS											1	1			
ANACYSTIS			2	2	2	3				1	3	2			
APHANIZOMENON						2									
CHROOCOCCUS										1	1	1			
DACTYLOCOCCOPSIS	1		1	3		1	1	2	1	3	2	1	1	2	1
GLOEOTHECE										1	1				

Table 9.(Continued)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LYNGBYA		2				3	1			1		1	2		
MERISMOPEDIA		2	2	1	1	3		2	1	1	3	1			1
OSCILLATORIA	3	3	2	2	3	3	2	1	2	2	1	2		1	2
RAPHIDIOPSIS											1				
SPIRULINA		1								1					
EUGLENOPHYTA															
CRYPTOGLENA			1			1									
EUGLENA	3	3	2	1	1	3	2	2	1	2	2	1	2	3	3
PHACUS		2	1												
TRACHELOMONAS		1		1	1	1	1	2		1	2	2	1	3	2
PYRROPHYTA															
GLENODINIUM		3	1	1		1		1		1	1	1	1	1	
GYMNODINIUM		2	1			1									1
PERIDINIUM		2												1	

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principal components 1, 2, and 3 accounted for 21 percent, 17 percent, and 13 percent, or together about 50 percent of the total variability within the data. Of the original 92 variates (taxa), those with values (eigenvectors) greater than 2.00 were selected as important factors in each independent component. Accordingly, the first component can be explained most readily by considering the four chlorophyte genera Coelastrum, Golenkinia, Oocystis, and Dictyosphaerium and the single cyanophyte genus Merismopedia. All five genera were correlated to the first component with the same algebraic sum (positive values) indicating a direct relationship. Study reach plots for the first (and second) components are shown in figure 23, indicating a clear separation of Hale Bridge, Dement Bridge, Estill Fork, and Lillards Mill from other study reaches. Examination of data showing distribution and abundance patterns among study reaches for these five phytoplankton genera identified organism abundance as the major factor responsible for study reach differences. Importance of organism abundance as the first principal component is also supported by earlier comparisons of study reach differences (one-way ANOVA and ranking of study reaches) based on total phytoplankton abundance (all taxa, table 8), which identified the same four reaches as having a larger phytoplankton community. All five genera were either most abundant (four genera) or greatly abundant (one genus) at Hale Bridge relative to the other 14 study reaches. All five genera were also abundant at Dement Bridge. Four of the five genera occurred together at Estill Fork and Lillards Mill. Greatest community diversity also occurred at these four study reaches, ranging from 41 taxa at Lillards Mill to 59 taxa at Hale Bridge.

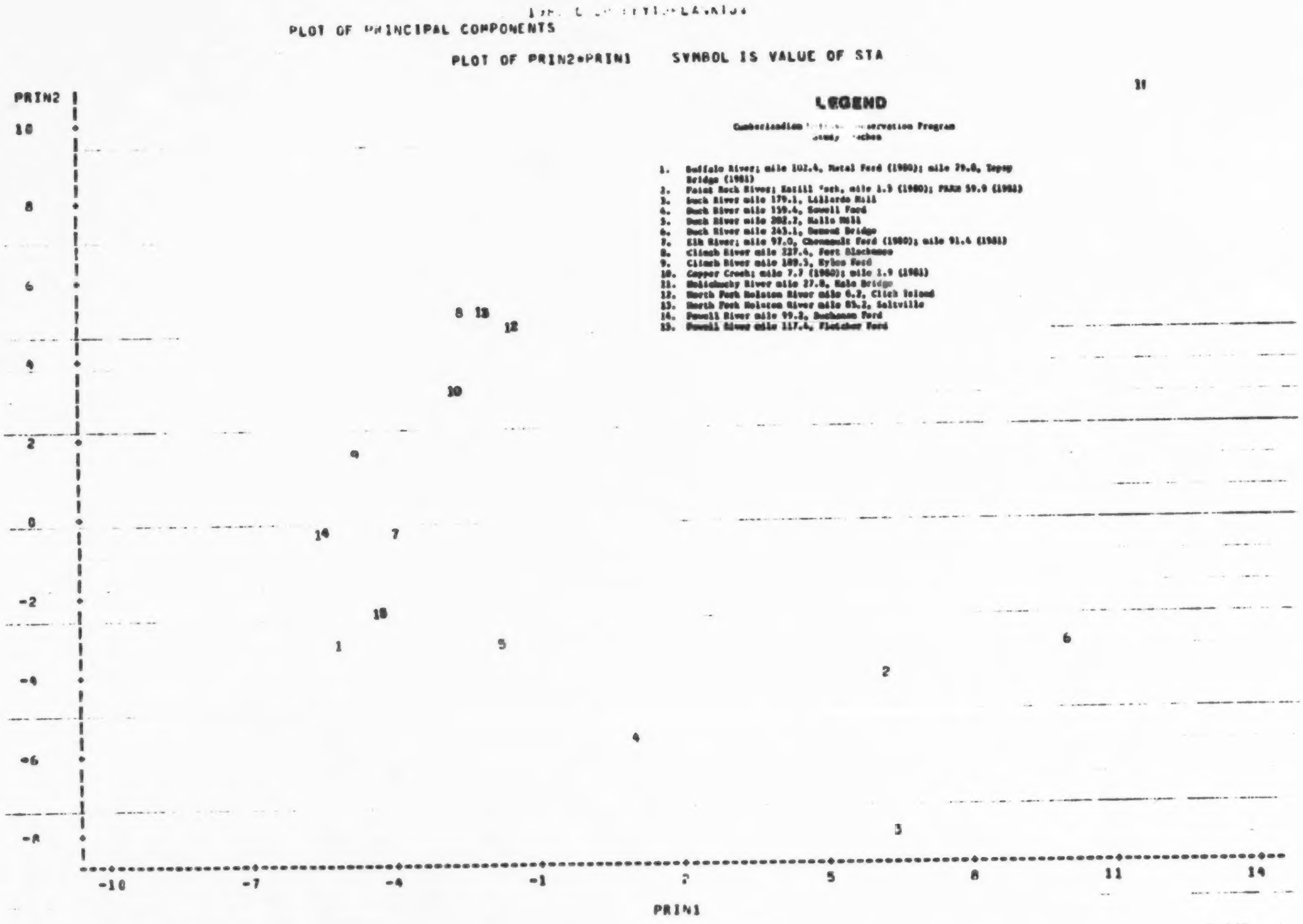


Figure 23. Comparison of Study Reaches Based upon the First and Second Principal Components of Phytoplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.

The second component contained both positive and negative values for major variates, indicating an inverse relationship. Hence, a presence/absence-type distribution of variates (taxa) relates best to the second principal component. Genera principally involved included two chrysophytes (Diatoma and Gyrosigma), two chlorophytes (Pandorina and Dictyosphaerium), and a single cryptomonad (Chroomonas). A plot of the second (and third) component is shown in figure 24. This component separated Kyles Ford, Copper Creek, Hale Bridge, Click Island, and Saltville from other study reaches based upon occurrence of Chroomonas together with the two chrysophyte genera. Hale Bridge was further separated by occurrence of a large population of Dictyosphaerium. Estill Fork, Lillards Mill, and Sowell Ford were unique as being the only reaches with the chrysophyte genus Pandorina.

The greatest difference among study reaches accounted for in principal component 3 (figure 24) was based on the presence/absence distribution of Dinobryon (Chrysophyta), Gonium and Ulothrix (Chlorophyta), and Lyngbya and Anacystic (Cyanophyta). Estill Fork (Paint Rock River) was the only study reach with a combination of Dinobryon, Gonium, Ulothrix, and Lyngbya. Occurrence of cyanophytes (Lyngbya and Anacystis) was largely responsible for separating all four Duck River study reaches from other reaches. None of the five major taxa in component 3 occurred at Metal Ford, Fort Blackmore, Kyles Ford, Buchanan Ford, and Fletcher Ford.

Similarity of 1981 study reaches based upon cluster analysis is shown in figure 25. As in 1980, Fort Blackmore, Copper Creek, Click Island, Kyles Ford, Buchanan Ford, and Fletcher Ford (Ridge and Valley Province study reaches) formed the largest primary cluster (E, similarity level = 0.6123). The Elk River reach (which was different from all other study

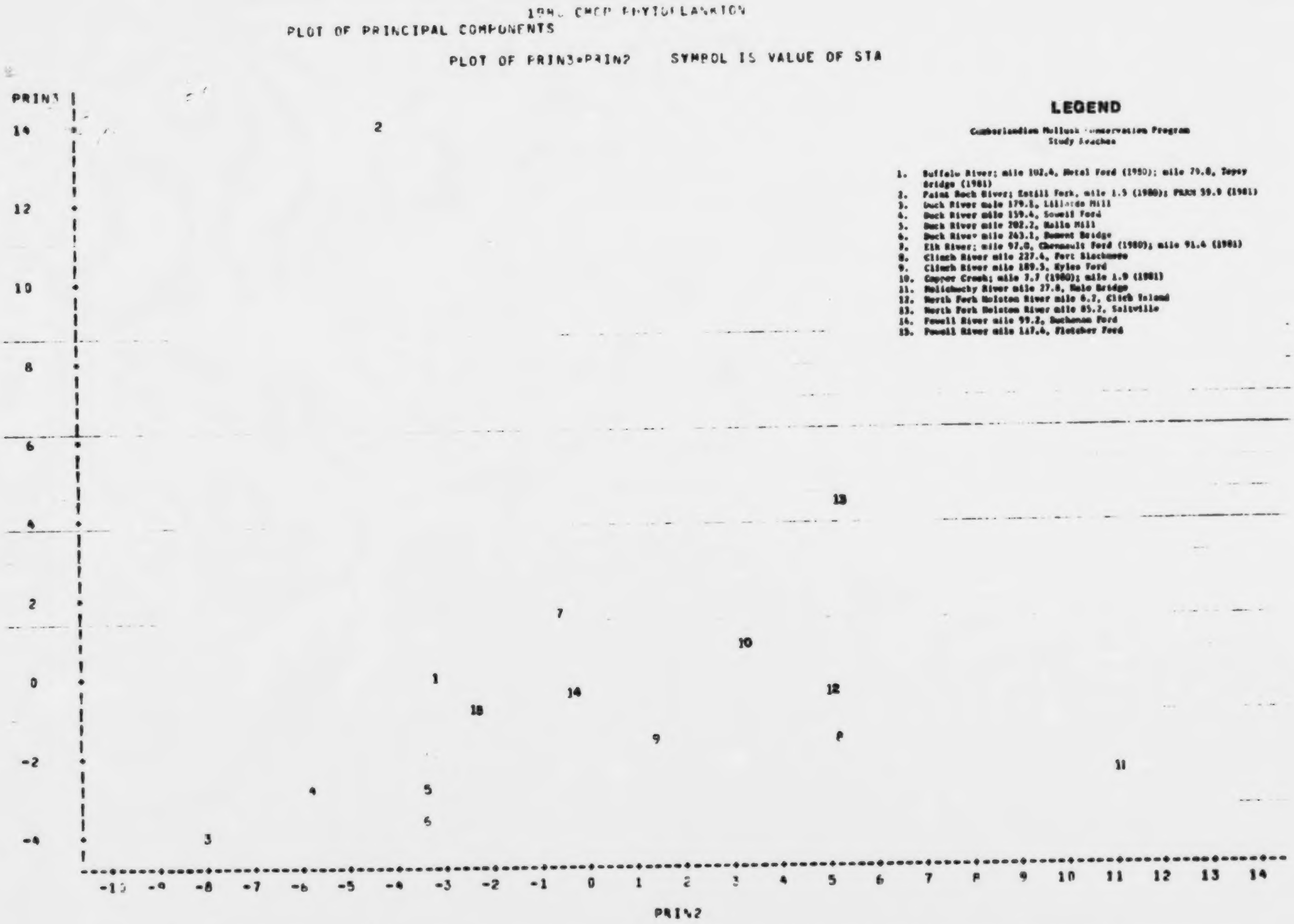
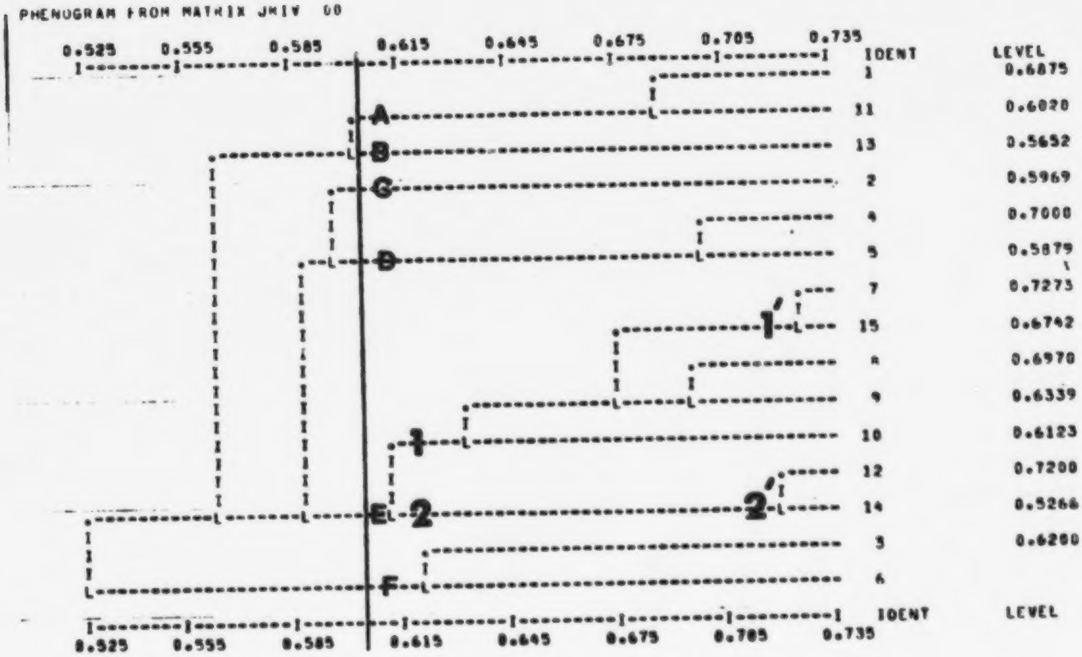


Figure 24. Comparison of Study Reaches Based upon the Second and Third Principal Components of Phytoplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.



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Cumberlandian Mollusk Conservation Program
Study Reaches

1. Buffalo River; mile 102.4, Metal Ford (1980); mile 79.8, Topey Bridge (1981)
2. Paint Rock River; Estill Fork, mile 1.1 (1980); PRRM 39.9 (1981)
3. Duck River mile 179.1, Lillards Mill
4. Duck River mile 159.4, Sowell Ford
5. Duck River mile 202.2, Halls Mill
6. Duck River mile 243.1, Dement Bridge
7. Elk River; mile 97.0, Chestnut Ford (1980); mile 91.4 (1981)
8. Clinch River mile 227.4, Fort Blackmore
9. Clinch River mile 189.3, Kyles Ford
10. Copper Creek; mile 7.7 (1980); mile 1.9 (1981)
11. Nolichucky River mile 27.8, Hale Bridge
12. North Fork Holston River mile 6.2, Cliff Island
13. North Fork Holston River mile 83.2, Saltville
14. Powell River mile 99.2, Buchanan Ford
15. Powell River mile 117.4, Fletcher Ford

Figure 25. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Phytoplankton Taxa Collected at Study Reaches, April through September 1981, Cumberlandian Mollusk Conservation Program.

reaches in 1980) joined cluster E in 1981 and was very similar (0.7273) to Fletcher Ford on the Powell River (cluster E-1'). Cluster E_2, also showed strong similarity (0.7200) between Click Island and Buchanan Ford study reaches. Duck River reaches were separated into clusters of Sowell Ford and Halls Mill (cluster D, 0.700) and Lillards Mill and Dement Bridge (cluster F, 0.6200). Separation of clusters D and F resulted from more phytoplankton taxa at Lillards Mill (46 genera) and Dement Bridge (49 genera) than at Sowell Ford (28 genera) and Halls Mill (17 genera), especially within the phytoplankton groups Chlorophyta and Cyanophyta. Hale Bridge which ranked first among study reaches in 1980 for total phytoplankton taxa (59) was much reduced in this aspect in 1981 (34 taxa) and clustered with the Buffalo River site (cluster A, 0.6875). A listing of genera occurring at each study reach is shown in table 10.

Analysis of study reaches based upon PCA showed the first three principal components respectively accounted for 25 percent, 16 percent, and 11 percent, or together about 51 percent of the variability within the data. Major variates or taxa for the first principal component included Pandorina (Chlorophyta), Trachelomonas (Euglenophyta), and the four cyanophyta genera Merismopedia, Anacystis, Aphanozomenon, and Spirulina. As was the case in 1980, principal component 1 for 1981 respresented organism abundance. However, there was a major difference between years in that important taxa in 1980 were primarily chlorophytes (all but one genus), while those in 1981 were predominately cyanophytes. Merismopedia (Cyanophyta) abundance was a major factor for both years. Study reach plots for the first component are shown in figure 26. Lillards Mill and Dement Bridge were very different from other study reaches because all six taxa occurred at these two reaches

Table 10. Phytoplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, April through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHLOROPHYTA															
ACTINASTRUM			1	1	1	2	2	1	1		2			1	2
ANKISTRODESMUS	1		3	2	2	2	2		2	1	3		2		2
ARTHRODESMUS			1												
CARTERIA			1										1		
CHLAMYDOMONAS	1	2	2	1	2	2	2	1		1	1	1	1	2	1
CHLORELLA		1	3	3	1		1	2	1		1	1			1
CHLOROGONIUM		2	3	2	1				1			1		2	2
CHODATELLA								1							1
CLADOPHORA						1									
CLOSTERIOPSIS	1				1	1					1				
CLOSTERIUM												1			
COELASTRUM						1		1	2						1
COSMARIUM	2					1		2	2	2	1	2	1	1	
CRUCIGENIA	2					2									
DACTYLOCOCCUS															1
DICTYOSPHAERIUM						1					1				
EUDORINA			2												
GOLENKINIA					1		1							1	
GONIUM	1	1	1								1		1		
KIRCHNERIELLA		1	3		1	1	1	1	2	1	1				1
MOUGEOTIA						1									
OOCYSTIS						1	1								
PANDORINA			3			1									
PEDIASTRUM			2		1			1			4				
PROTOCOCCUS			1	1				1							
PTEROMONAS											1				
PYRAMIMONAS			1				1								
QUADRIGULA							1								
RHIZOCLONIUM	1														
SCENEDESMUS	2	1	5	2	5	4	4	4	5	3	5	3	4		2
SCHROEDERIA	1		3		2	4	1	2		1	3	1		2	2
SPERMATOZOOPSIS			1	1	1		1								
STAURASTRUM						1									
STIGEOCLONIUM	1												1	2	
TETRASTRUM			1		1	1									
ULOTHRIX	1														
CHRYSOPHYTA															
ACHNANTHES	4	5	4	2	4	4	4	4	3	5	5	4	5	4	5
AMPHIPRORA							1								
ASTERIONELLA											1				

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60

Table 10. (Continued)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CALONEIS											1				
CHAETOCEROS						1									
COCCONEIS	5	5	1	4	5	1	3	5	5	5	4	5	5	5	5
CYCLOTELLA			2			2	1	1		1					1
CYMATOPLEURA						1									3
CYMBELLA	5	4	2	4	4	5	3	5	5	5	5	5	5	4	5
DIATOMA			1	1	1	1	4	5	5	3	5	3	3	5	5
DICHOTOMOCOCCUS					1										
DINOBRYON											1			1	1
EPITHEMIA	1					2							1		
EUNOTIA													1		
FRAGILARIA									1		1				
GOMPHONEMA	2	3	4	1	2	1	3	3	2	3	3	2	4	3	3
GYROSIGMA	2	1	3			3	1	1	1	2	1	3	1	2	2
MALLOMONAS	1		1												
MELOSIRA	5	1	4	3	5	5	4	3	2	3	4	2	2	4	3
MERIDION	1		1						1		1				
NAVICULA	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5
NITZSCHIA	5	3	4	3	3	5	4	4	3	5	5	5	5	5	4
PLEUROSIGMA				1								1			
RHIZOSOLENIA						1		1	1			1			
RHOICOSPHENIA	1	1	1		1	1	1	4	3			3	1	2	4
STEPHANODISCUS	2	1	4	1	2	2	2	2	1	2	3	1		3	3
SURIRELLA	2	1	2	1			2	3	2	3	3	1	2	3	2
SYNEDRA	5	5	5	4	5	5	4	4	5	5	5	5	5	5	5
SYNURA						1		1					1		1
CRYPTOPHYTA															
CRYPTOMONAS	1	1	3	1	2	2	2				1				1
CYANOPHYTA															
ANABAENA						1									
ANABAENOPSIS						1									
ANACYSTIS			1			3									
APHANIZOMENON			1			1									
DACTYLOCOCCOPSIS	2	1	5	3	4	5	3	4	3	2	4		1	1	3
LYNGBYA						1									
MERISMOPEDIA	1		4	3	3	4	1	2	2	1	1		2		
OSCILLATORIA		2	1	1		3		1		1		1	1		
SPIRULINA			1			2									
EUGLENOPHYTA															

61

Table 10. (Continued)

	STUDY REACH														
TAXA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRYPTOGLENA				1											
EUGLENA		2	5	1	4	4	2	4	1		3	1	3	1	1
PHACUS			3	1		1	1								
TRACHELOMONAS		1	4		2	2	1	1							
PYRROPHYTA															
CERATIUM				1											
GLENODINIUM		1	3		1	1									
GYMNODINIUM			1												

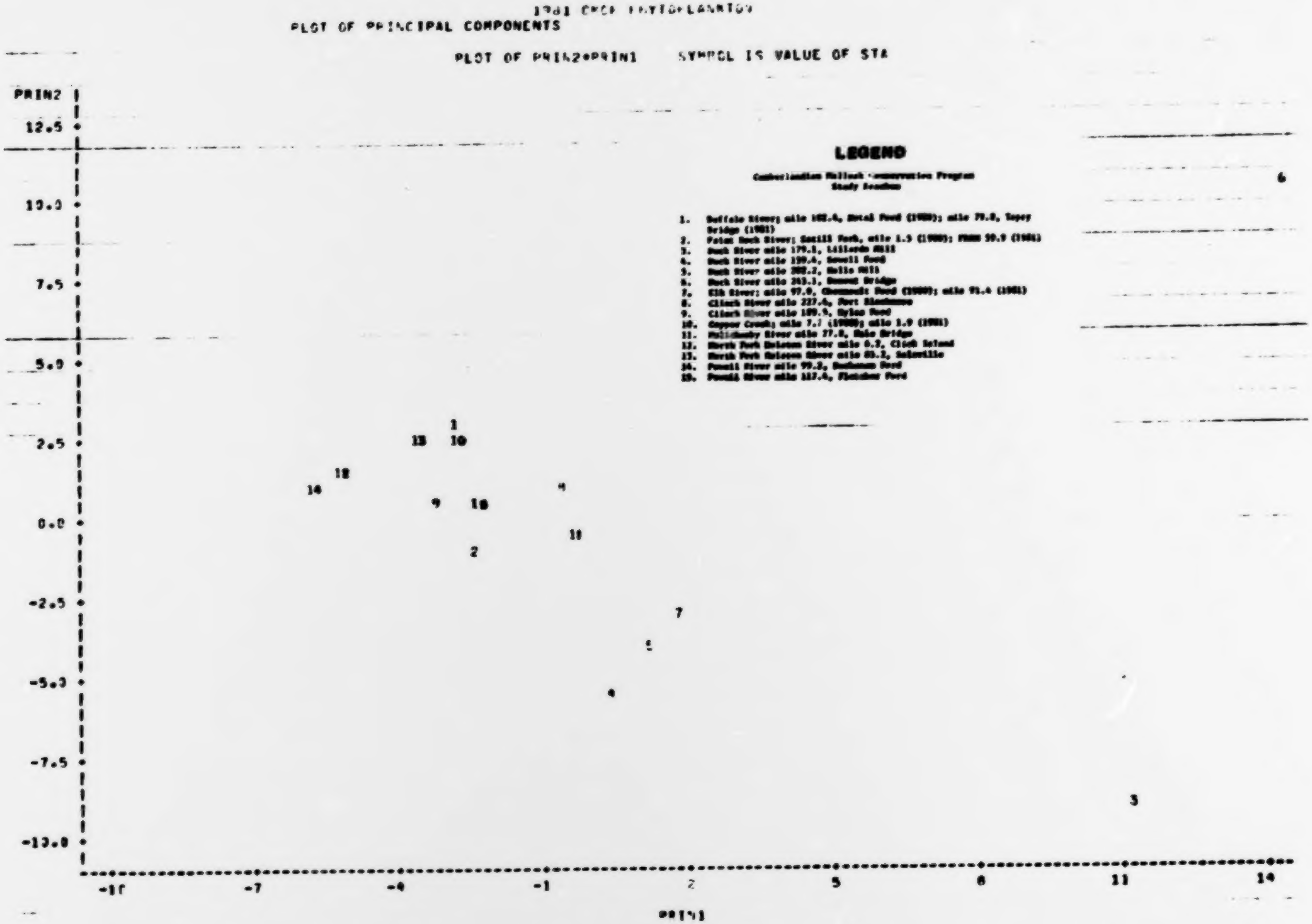

Figure 26. Comparison of Study Reaches Based upon the First and Second Principal Components of Phytoplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program.

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with the maximum abundance of *Pandorina*, *Trachlemonas*, and *Merismopedia* occurring at Lillards Mill and maximum abundance of *Anacystis*, *Aphanozomenon*, and *Spirulina* occurring at Dement Bridge.

Major taxa affecting station differences based upon the second component (figure 27) were *Cosmarium*, *Chlorella*, *Chlorogonium*, and *Spermatozoopsis* (Chlorophyta) and *Lyngbya* (Cyanophyta). Positive and negative values for major variates again related principal component 2 with a presence/absence-type distribution of taxa. Whereas Lillards Mill and Dement Bridge study reaches were similar regarding the first component, they were extremely different regarding principal component 2. *Chlorella*, *Chlorogonium*, and *Spermatozoopsis* (loaded negatively into the analysis) were all present at Lillards Mill and absent at Dement Bridge while *Cosmarium* and *Lyngbya* (loaded positively into the analysis) both occurred at Dement Bridge but were not found at Lillards Mill.

Major variates in the third principal component consisted of *Gonium*, *Chlorella*, *Actinastrum*, *Coelastrum*, and *Diatoma*. The presence of Gonium (loaded negatively) only at Topsy Bridge, Paint Rock River, Lillards Mill, Hale Bridge, and Saltville accounted for negative distribution of those study reaches (figure 27). Fort Blackmore, Fletcher Ford, and Kyles Ford were unique in being the only reaches where *Chlorella*, *Actinastrum*, *Coelastrum*, and *Diatoma* occurred together.

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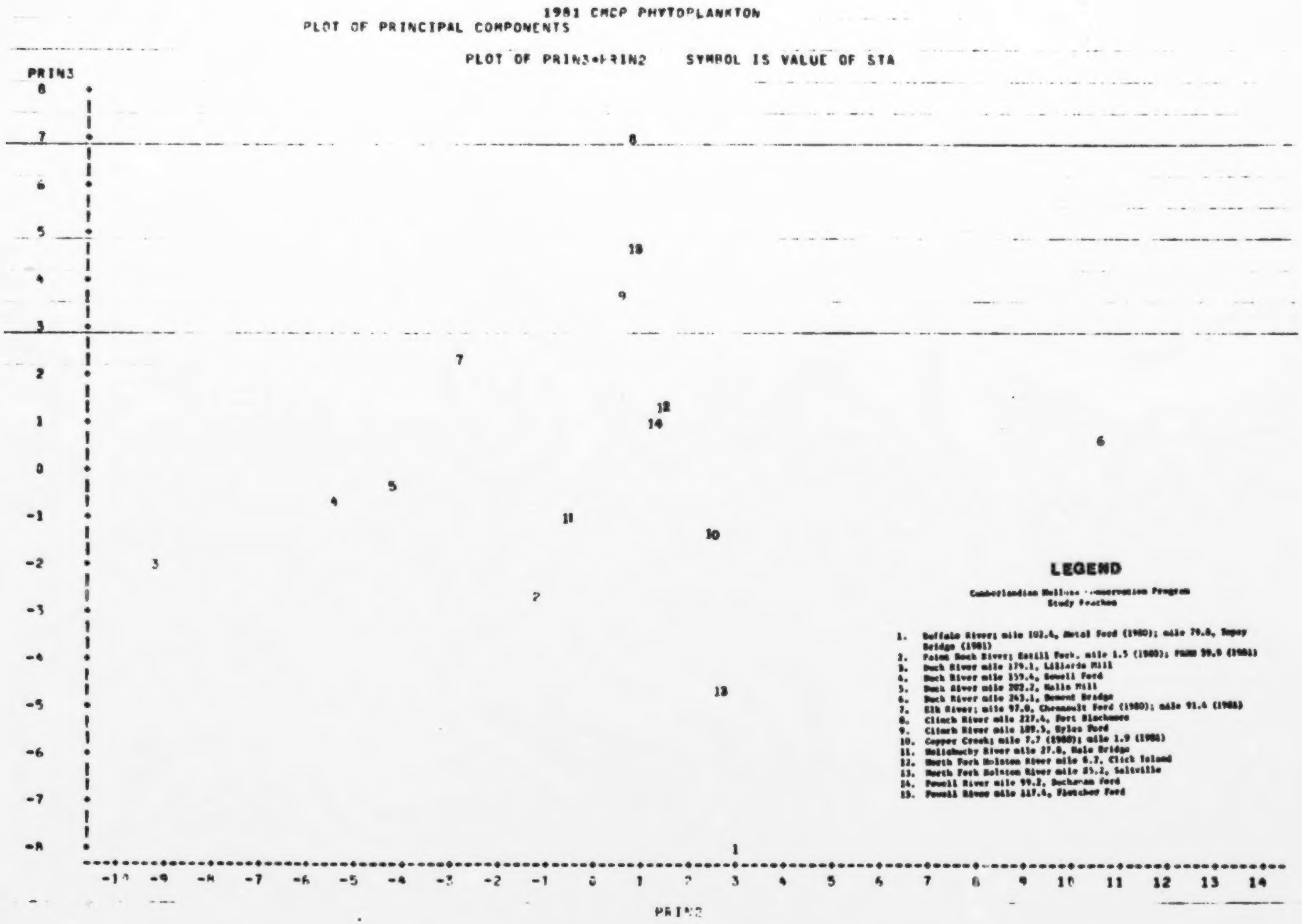


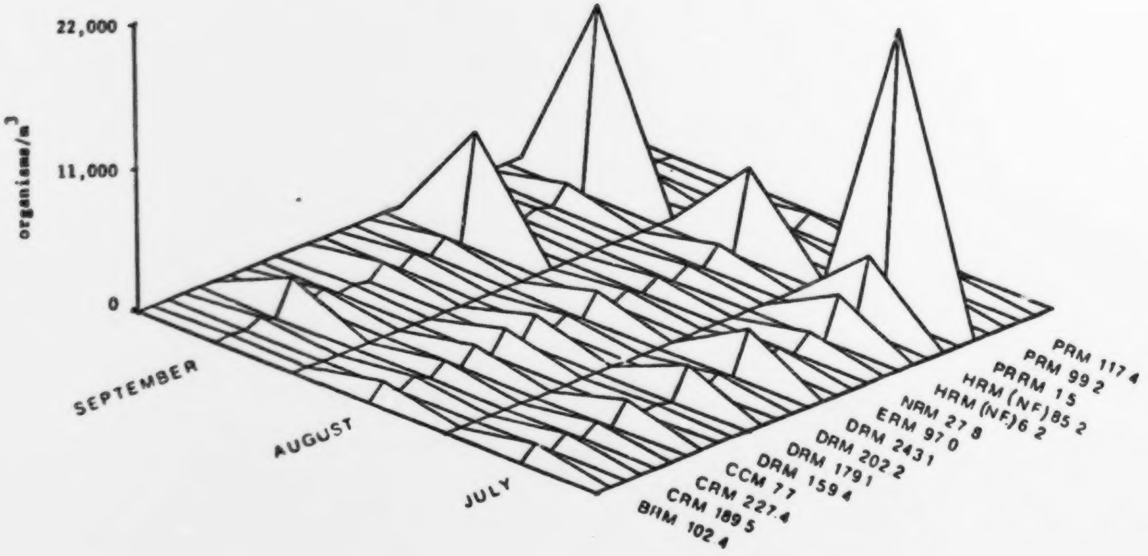
Figure 27. Comparison of Study Reaches Based upon the Second and Third Principal Components of Phytoplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program.

Zooplankton

Abundance--Zooplankton data (provided in appendix E) are illus-trated in figures 28 and 29 for 1980 and 1981, respectively. While zooplankters do not constitute a major part of the mussel diet, they compose a part of the transported biomass and therefore are considered in this analysis.

In 1980, greatest zooplankton abundance occurred at Estill Fork Mile 1.5 (Paint Rock River), a study reach which was discontinued in 1981 due to observed water quality problems. Preponderance of zooplankton at this location resulted from sluggish flow and a great abundance of aquatic macrophytes. In addition to Estill Fork; Chennault Ford (Elk River), Hale Bridge, Dement Bridge, and Lillards Mill composed the upper one-third of the study reaches based on zooplankton abundance. All locations were dominated by rotifers which were most abundant at Estill Fork, Chennault Ford, Hale Bridge, and Dement Bridge.

In 1981 (figure 29), Dement Bridge far surpassed other reaches in zooplankton abundance (7,615 organisms/m^3, mean of 5 months). The 34,706 organisms/m^3 which occurred in April likely resulted from a release from Normandy Reservoir located 8.8 kilometers (5.5 miles) upstream. The second most productive study reach (combined months) and site with the greatest consistent monthly abundance was Lillards Mill. Other locations on the Duck River and the reach at Paint Rock River Mile 60.0 demonstrated late seasonal (July through September) abundance. Early spring (April) abundance was apparent at most locations, especially at those on the Elk and North Fork Holston Rivers (see figure 30 with April data for Dement Bridge removed for greater illustrative purposes). Rotifers (appendix F) dominated 8 of the 15 study reaches: Topsy Bridge, Lillards Mill, Sowell Ford, Elk River,



CMCP 1980

TOTAL ZOOPLANKTON

Figure 28. Monthly Zooplankton Abundance at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980.

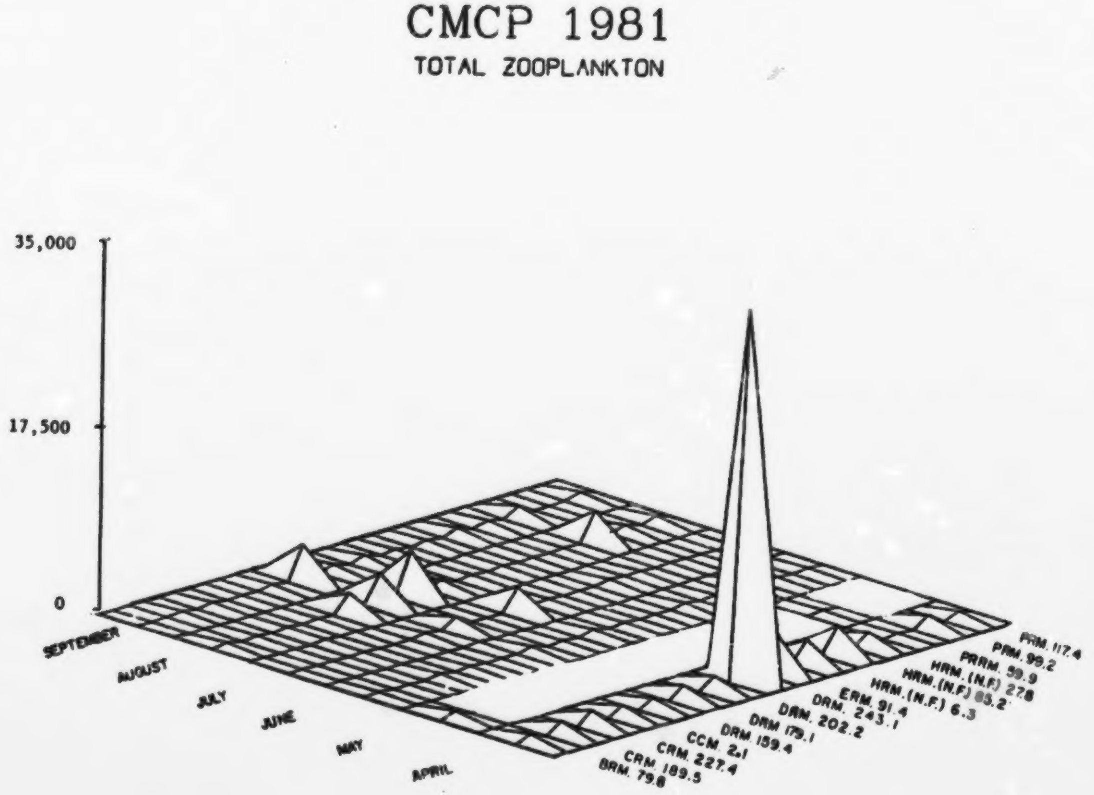


Figure 29. Monthly Zooplankton Abundance at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981.

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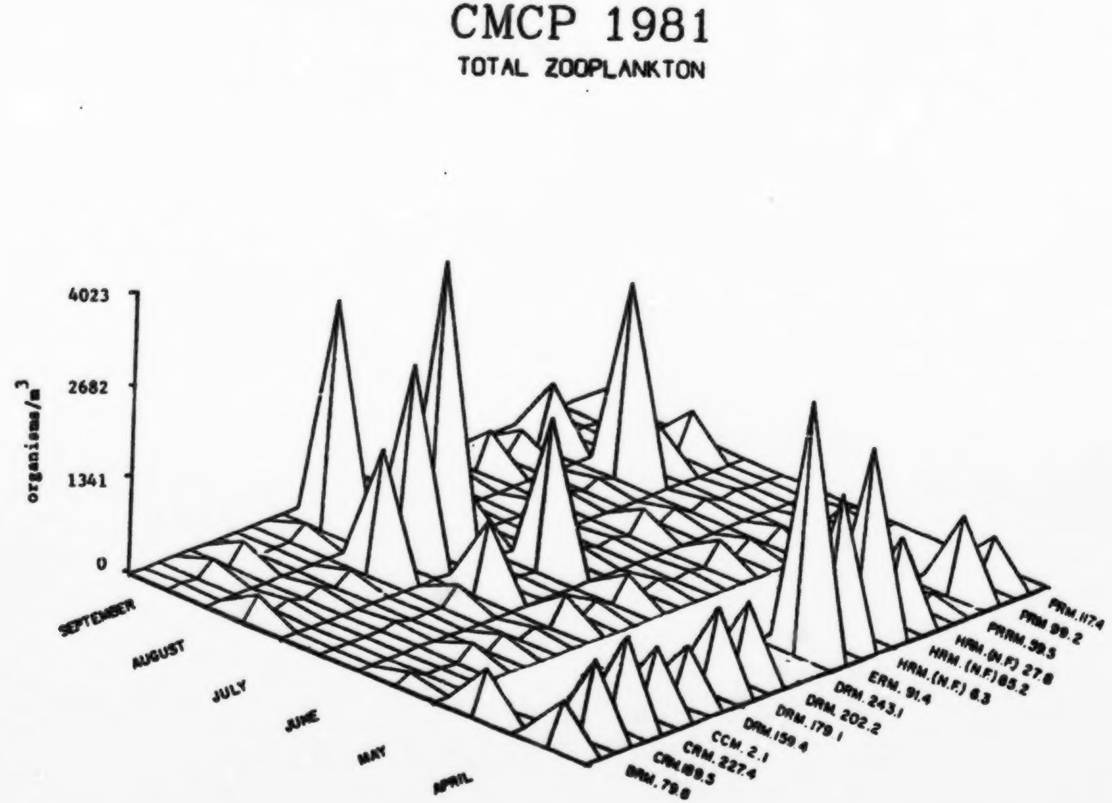

Figure 30. Monthly Zooplankton Abundance at Designated Reaches, Cumberlandina Mollusk Conservation Program, 1981 (April Data at DRM 243.1 Deleted to Better Illustrate Differences Among Other Sites).

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Fort Blackmore, Copper Creek, Saltville, and Fletcher Ford. The remaining seven locations were dominated (yearly means) by copepods, although other groups (i.e., rotifers) were more prevalent in isolated months.

Statistical treatment of zooplankton data is shown in table 11 for both total and major zooplankton groups (Cladocera, Copepoda, and Rotifera). Variability in total abundance explained by site differences was much greater in 1980 ($R^2 = 0.54$) than in 1981 ($R^2 = 0.23$) as is evidenced by the great deal of overlapping among study reaches in 1981 (table 11). Yearly differences in abundance and the large degree of overlapping in 1981 made it difficult to distinguish consistent trends in reach similarity. Reaches 3, 5, 6, 7, and 11 (Lillards Mill, Halls Mill, Dement Bridge, Elk River, and Hale Bridge) usually grouped together as locations with greatest zooplankton abundance.

Community structure--Distribution of zooplankton taxa among study reaches in 1980 is provided in table 12. Presence/absence data grouped the study reaches into four primary clusters (A through D, figure 31). Greatest similarity among study reaches occurred within cluster A with Metal Ford and Click Island being very similar (level = 0.722, cluster A_1,) and also Halls Mill and Kyles Ford (0.7083, A_2,). Other than these two clusters, level of association was low as primary clusters (similarity <0.60) contained mostly poorly associated reaches. Estill Fork (43 taxa) and Hale Bridge (33 taxa), which were the most diverse study reaches, clustered together (D), but had a low degree of similarity (0.5798).

Analysis of study reaches based upon PCA showed the first three principal components respectively accounted for 34 percent, 13 percent, and

Table 11. Zooplankton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Year	Zooplankton Group	Degrees of Freedom (Treatment, Error)	F-Value	P >F	Statistically Similar Reaches (α = 0.05)*															R^2
					Lowest														Highest	
1980	Total	(14, 75)	6.30	0.0001	15	1	4	12	9	5	14	13	10	8	3	6	7	11	2	0.540
	Cladocera	(14, 75)	2.06	0.0241	7	12	9	15	10	1	6	13	5	8	4	14	11	3	2	0.278
	Copepoda	(14, 75)	5.92	0.0001	12	4	8	14	9	1	7	12	13	11	5	3	10	6	2	0.525
	Rotifera	(14, 75)	3.12	0.0007	4	1	14	15	9	3	5	12	10	13	8	6	11	7	2	0.368
1981	Total	(14, 132)	2.81	0.0011	9	10	1	12	14	8	15	2	11	7	4	13	5	6	3	0.229
	Cladocera	(14, 132)	2.61	0.0023	9	15	10	11	1	14	12	8	4	2	13	7	6	5	3	0.217
	Copepoda	(14, 132)	2.04	0.0194	10	1	9	8	12	15	13	2	14	11	7	6	4	5	3	0.178
	Rotifera	(14, 132)	2.24	0.0093	9	12	11	1	14	10	2	8	7	4	15	5	13	3	6	0.192

*All reaches underscored by the same line are similar. Rankings are based on log transformed data.

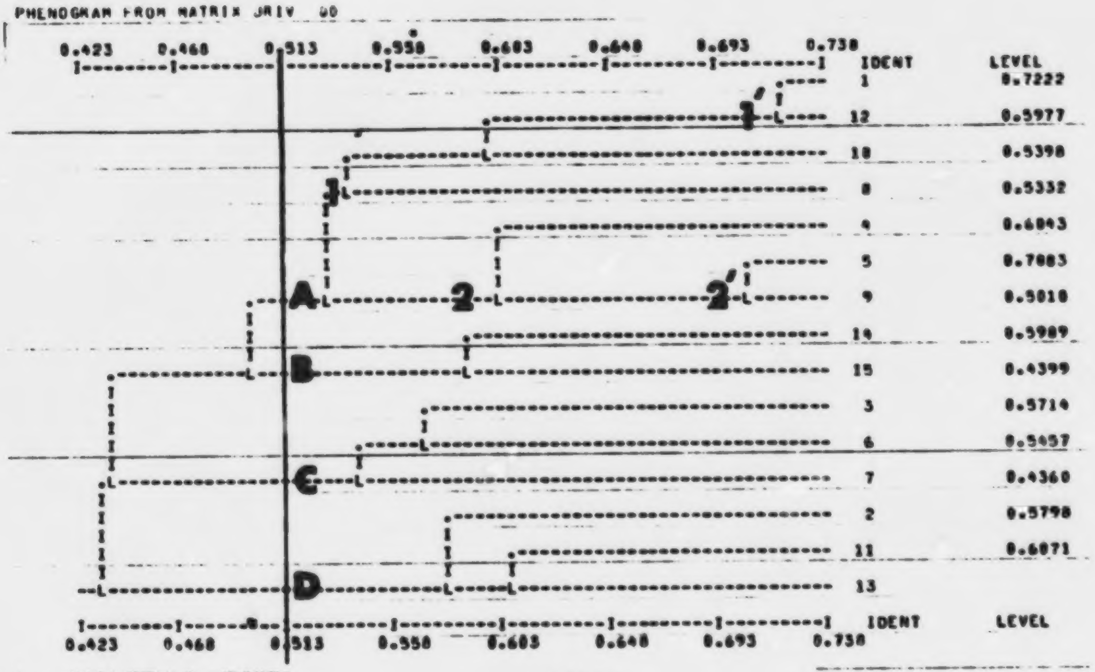
Reaches:
1. Buffalo River; Metal Ford (1980), Topsy Bridge (1981)
2. Paint Rock River; Estill Fork (1980), Mile 60 (1981)
3. Duck River, Lillards Mill
4. Duck River, Sowell Ford
5. Duck River, Halls Mill
6. Duck River, Dement Bridge
7. Elk River; Chennault Ford (1980), Mile 91.4 (1981)
8. Clinch River, Fort Blackmore
9. Clinch River, Kyles Ford
10. Copper Creek; Mile 7.7 (1980), Mile 1.9 (1981)
11. Nolichucky River, Hale Bridge
12. North Fork Holston River, Click Island
13. North Fork Holston River, Saltville
14. Powell River, Buchanan Ford
15. Powell River, Fletcher Ford

Table 12. Zooplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLADOCERA															
ALONA COSTATA		1						1		2	2		1		
ALONA INTERMEDIA											1		1		
BOSMINA LONGIROSTRIS	3	3	2	3	2	3	2	2	2	1	3	2	2	2	2
CERIODAPHNIA IMM.					1										
CHYDORUS SP.		3			1				1					1	
DAPHNIA IMM.											1				
DAPHNIA PARVULA						1									
DAPHNIA RETROCURVA		1			1						1		1		
DIAPHANOSOMA LEUCHTENBERGIANUM		1	3	1			1		1		1		1	1	
ILYOCRYPTUS IMM.				2						1	1			1	1
KURZIA LATISSIMA		2							1						
LEPTODORA KINDTII					1										
MOINA IMM.			2	1	1										
MOINA MINUTA			1	1											
PLEUROXUS DENTICULATUS		2													1
PLEUROXUS HAMULATUS			1												
SIMOCEPHALUS SERRULATUS		1													
COPEPODA															
CALANOIDA IMM.		1									1		1	1	
CYCLOPOIDA IMM.	2	3	2	2	3	3	1	1	2	1	2	1	2	2	1
CYCLOPS VARICANS RUBELLUS		1													
CYCLOPS VERNALIS					1										
DIAPTOMUS PALLIDUS											1				
DIAPTOMUS REIGHARDI											1				
ELAPHOIDELLA BIDENS CORONATA					1								1		
ERGASILUS IMM.			1											1	
EUCYCLOPS AGILIS		2		1	2				1			1			1
EUCYCLOPS PRIONOPHORUS		1													
HARPACTICOID IMM.	1						1			1			2	1	
HARPACTICOIDA													1		
MACROCYCLOPS ALBIDUS		2				1									
MESOCYCLOPS EDAX		1	1			1		1			1				
NAUPLII	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
TROPOCYCLOPS PRASINUS		3	1		1										
ROTIFERA															
ASPLANCHNA AMPHORA	1	1				1									
ASPLANCHNA HERRICKI		1	1			1					1	1	1		

Table 12. (Continued)

TAXA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						STUDY REACH									
BDELLOIDEA			1			1	1						1		
BEUCHAMPIELLA SP.											1				
BRACHIONUS ANGULARIS	3	1	3	3	3	3	3	3	3	3	2	3	2	3	1
BRACHIONUS BIDENTATA	1														
BRACHIONUS BUDAPESTINENSIS	2	1	1	2	3	1	1	2	1	2	2	2	1	1	1
BRACHIONUS CALYCIFLORUS			1								3	1			
BRACHIONUS CAUDATUS	1	1	1	1	1	1	2	3	1	1	3	2	2	1	2
BRACHIONUS HAVANAENSIS											1				
BRACHIONUS NILSONI									1						
BRACHIONUS QUADRIDENTATUS	1		1								1				
CEPHALODELLA SP.	1	1							1	1		1	1	1	2
COLLOTHECA SP.		1								1	1			1	
COLURELLA SP.											1		1		
CONOCHILOIDES SP.	2	1	1	1	1			3	1	1	1	2			
CONOCHILUS HIPPOCREPIS			1					1							1
CONOCHILUS UNICORNIS		1						1			1				
CONTRACTED ROTIFERA	1	3	1	2	1	3	2	2	3		2	2	2	2	2
EPIPHANES MACROURUS		2	1		1		1		1						1
EUCHLANIS SP.	2	2	2	1	1	3	3	3	3	3	2	2	1	2	3
HEXARTHRA MIRA			2				1								
KELLICOTTIA BOSTONIENSIS						1									
KERATELLA COCHLEARIS						1			1						
KERATELLA EARLINAE		1				1	1						1		
KERATELLA SP.						1									
LOPHOCHARIS SALPINA											1				
MACROCHAETUS SUBQUADRATUS		1	1			1				1			1		
MONOMMATA GRANDIS						1									
MONOSTYLA BULLA		1													
MONOSTYLA QUADRIDENTATA		1			1	1									
MONOSTYLA SP.		2	1			2	1	2							
MYTILINA SP.		2													
NOTHOLCA SP.		1										1			
NOTOMMATA SP.	1	1													
PLATYIAS PATULUS		3		1	1			1		2	1		2	1	2
PLATYIAS QUADRICORNIS	1	1		1											
PLOESOMA SP.														1	
PLOESOMA TRUNCATA	2		1		1	3	1	1	1	1		1			
POLYARTHRA SP.	2	3	2	2	2	1		2	1	2	3	1	1	1	
ROTARIA SP.				1	1		2	1	1		1				
SYNCHAETA SP.	2	2	2	1	1	3	1		2	1		1		1	1
SYNCHAETA STYLATA		1									1		2		
TESTUDINELLA SP.		2	1				1				1		1	1	1
TRICHOCERCA SP.			1		1				1					1	
TRICHOTRIA SP.							1			1					



LEGEND

Cumberlandian Mollusk Conservation Program
Study Reaches

1. Buffalo River; mile 102.4, Metal Ford (1980); mile 79.8, Topsy Bridge (1981)
2. Paint Rock River; Estill Fork, mile 1.5 (1980); PRRM 50.9 (1981)
3. Duck River mile 179.1, Lillards Mill
4. Duck River mile 130.4, Sowell Ford
5. Duck River mile 202.2, Halls Mill
6. Duck River mile 243.1, [illegible] Bridge
7. Elk River; mile 97.0, [illegible] Ford (1980); mile 91.4 (1981)
8. Clinch River mile 227.4, Fort Blackmore
9. Clinch River mile 189.5, Kyles Ford
10. Copper Creek; mile 7.7 (1980); mile 1.0 (1981)
11. Nolichucky River mile 27.8, Hale Bridge
12. North Fork Holston River mile 6.2, [illegible] Island
13. North Fork Holston River mile 85.2, Saltville
14. Powell River mile 99.2, Buchanan Ford
15. Powell River mile 117.4, Fletcher Ford

Figure 31. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Zooplankton Taxa Collected at Study Reaches, July through September 1980, Cumberlandian Mollusk Conservation Program.

10 percent, or together about 57 percent of the total variability within the data. Important variates (eignevectors >0.200) for the first three principal components were as follows.

Component 1	Component 2	Component 3
Platyias quadricornis	*Ploesoma truncata*	*Conochiloides* sp.
Platyias patulus	*Synchaeta* sp.	*Asplanchna herricki*
Synchaeta stylata	*Synchaeta stylata*	*Keratella earlinae*
Monostyla sp.	*Platyias patulus*	*Synchaeta stylata*
Monostyla quadridentata	Bdelloidea	Bdelloidea
Chydorus sp.		

With only one exception (*Chydorus*:Cladocera), rotifers were responsible for major differences among study reaches.

The first principal component (organism abundance) separated Estill Fork from all other study reaches (figure 32). Maximum abundance of *Platyias quadricornis*, *Synchaeta stylata*, *Monostyla* sp., *Monostyla quadridentata*, and *Chydorus* sp. occurred at this study reach.

The second component separated Lillards Mill, Dement Bridge, and the Elk River from other study reaches (figure 33) based on the occurrence together of Bdelloidea, *Synchaeta* sp., and *Ploesoma truncata*. Absence of these taxa and presence of *Synchaeta stylata* and *Platyias patulus* (loaded negatively into the analysis) separated Hale Bridge on the Nolichucky River from all other study reaches.

The third principal component separated Elk River, Lillards Mill, Dement Bridge, Hale Bridge and Saltville from other study reaches as shown in figure 33. This separation was based upon the occurrence of Bdelloidea only at Lillards Mill, Dement Bridge, Elk River, and Saltville and the absence of *Conochiloides* at Dement Bridge, Elk River, and Saltville. None of the major taxa occurred at the two study reaches on the Powell River.

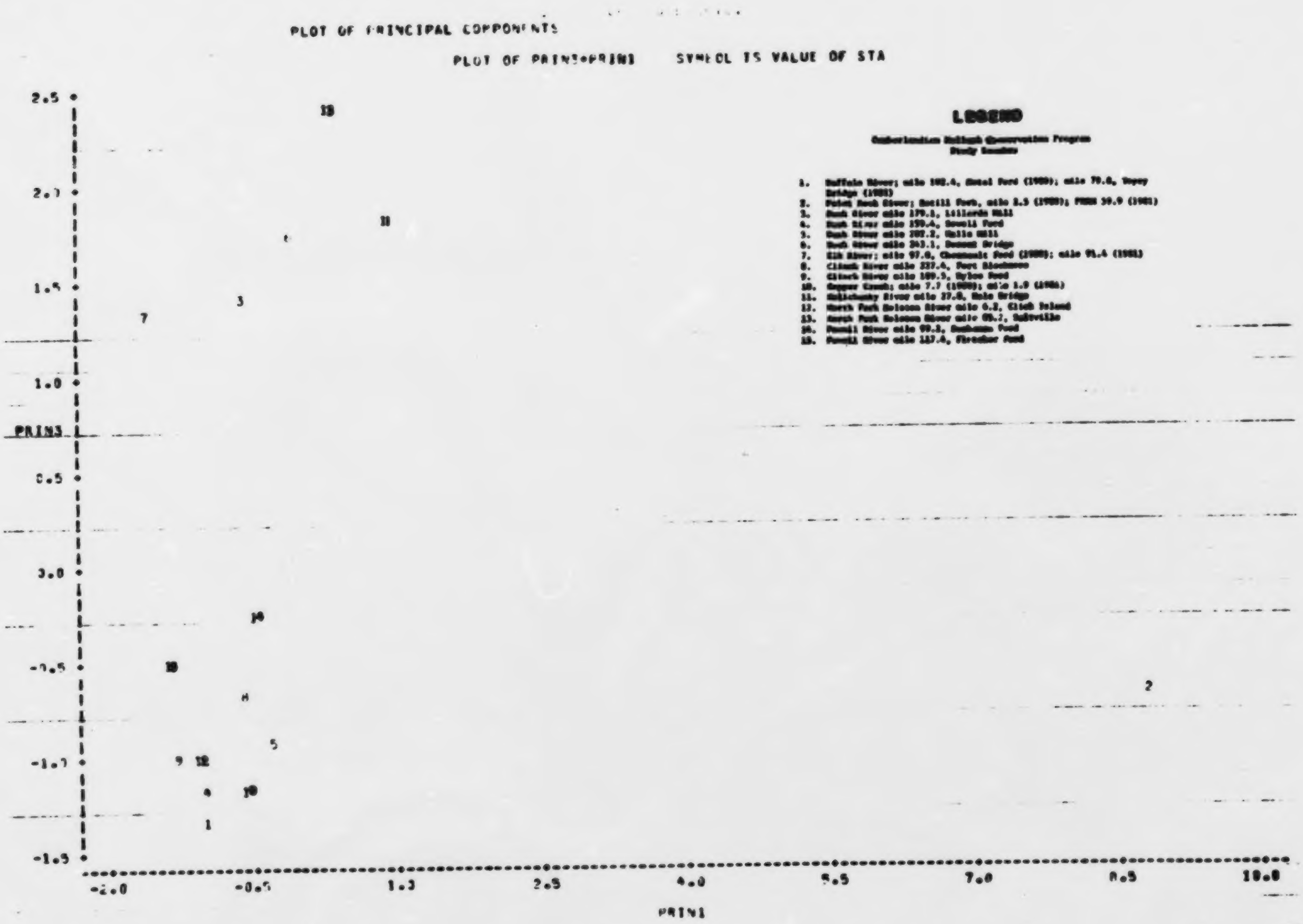


Figure 32. Comparison of Study Reaches Based upon the First and Third Principal Components of Zooplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.

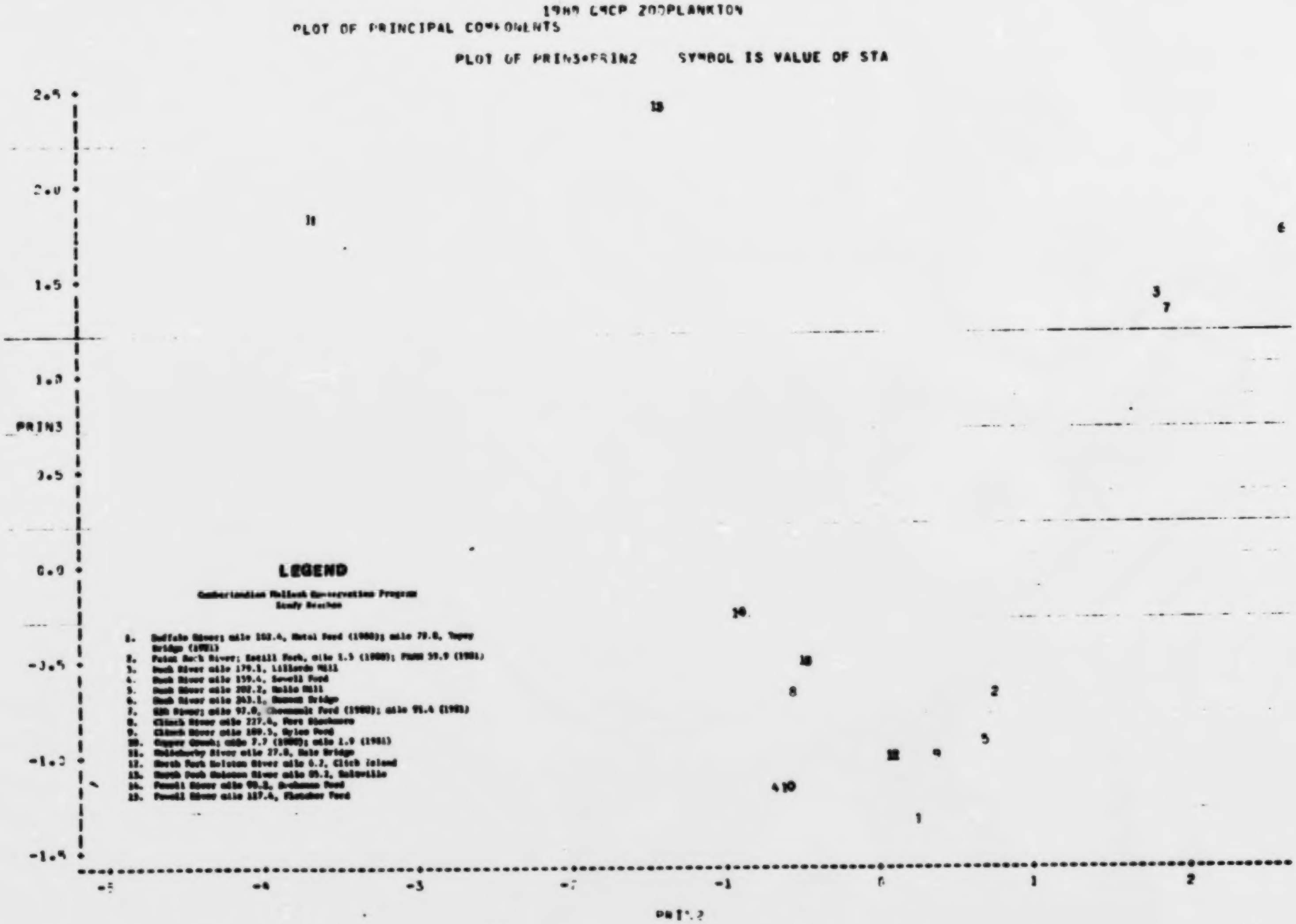


Figure 33. Comparison of Study Reaches Based upon the Second and Third Principal Components of Zooplankton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.

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Cluster analysis of 1981 zooplankton data separated study reaches into five primary clusters. Cluster C (figure 34), which contained all four Duck River study reaches and the study reach on the Elk River, further separated these reaches into two groups based upon faunal associations: Cluster C_1 composed of the Lillards Mill, Halls Mill, and Sowell Ford study reaches (similarity $\geq$ 0.5890) and C_2 composed of Dement Bridge and Elk River study reaches (similarity $\geq$ 0.6471). Closest association of the 15 reaches was between Fort Blackmore and Click Island (similarity = 0.7500, cluster $B_{1,}$). Study reaches in Cluster A (Topsy Bridge, Saltville, and Fletcher Ford) were not very similar while Hale Bridge (Cluster D) and Kyles Ford (Cluster E) were entirely different from each other and other study reaches. A list of taxa occurring at each study reach is provided in table 13.

PCA analysis of 1981 zooplankton accounted for 28 percent, 17 percent, and 12 percent respectively for the first three components or together about 56 percent of the total variability. While study reach differences in 1980 were caused principally by rotifers, in 1981 rotifers, cladocerans, and copepods combined to account for location differences. Major taxa for the first three components were as follows.

Component 1	Component 2	Component 3
Bdelloidea	*Platyias quadricornis*	Bdelloidea
Euchlanis sp.	*Synchaeta* sp.	*Trichotria* sp.
Cephalodella sp.	*Brachionus quadridentata*	*Brachionus candatus*
Synchaeta sp.	*Platyies patulus*	*Cephalodella* sp.
Platyias patulus	*Bosminopsis* sp.	*Bosmina longirostris*
Bosmina longirostris	*Daphnia ambigua*	Cyclopoid copepodids
Chydorus sp.	*Daphnia* instars	
Bosminopsis sp.		
Cyclopoid copepodids		
Mesocyclops edax		

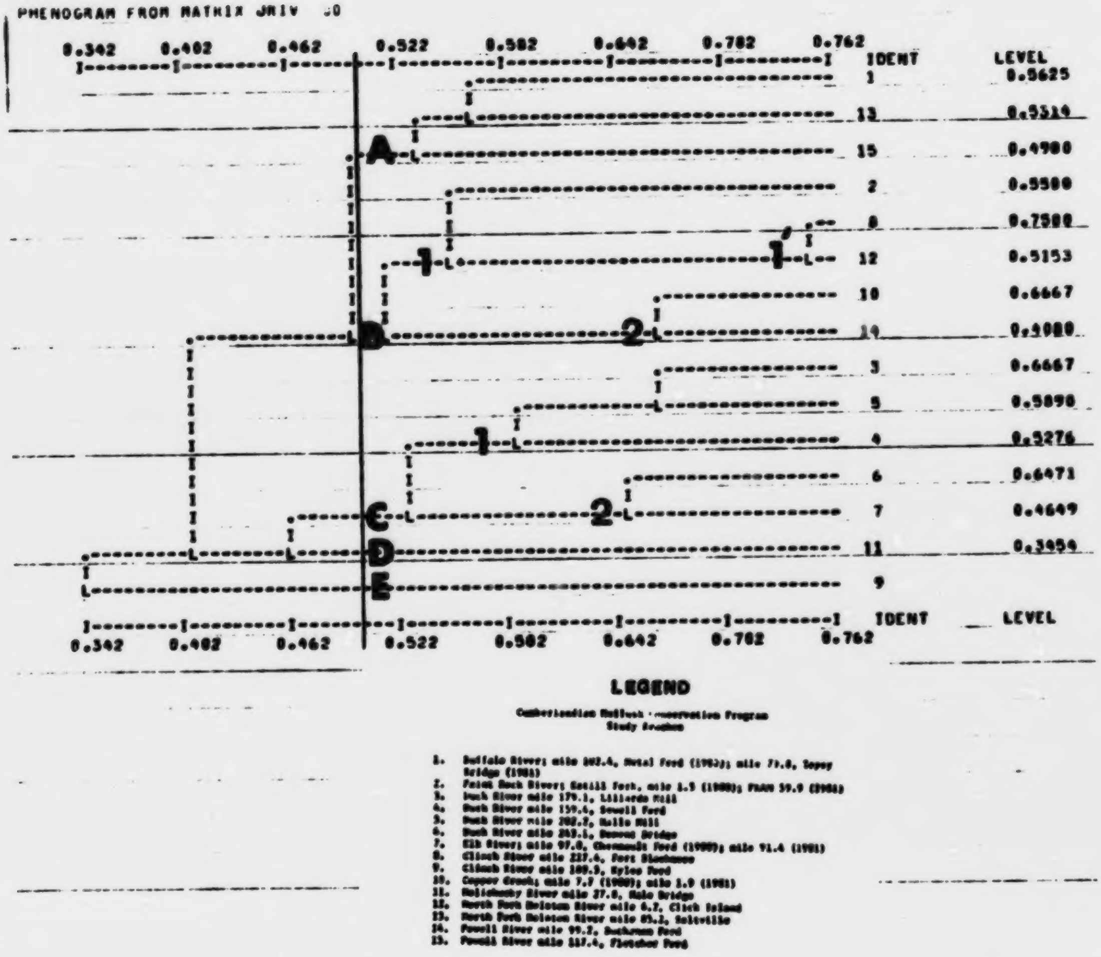

Figure 34. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Zooplankton Taxa Collected at Study Reaches, April through September 1981, Cumberlandian Mollusk Conservation Program.

Table 13. Zooplankton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, April through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLADOCERA															
ALONA GUTTATA		1						1				1			
ALONA IMM.		2								1			1		
ALONA RECTANGULA							1								
BOSMINA LONGIROSTRIS	2	2	5	4	3	3	2	2		1	1	3	3	2	2
BOSMINOPSIS SP.						1									
CERIODAPHNIA LACUSTRIS			1		1										
CHYDORUS SP.			2	1		2	2	1				1	1		1
DAPHNIA AMBIGUA						1	1								
DAPHNIA IMM.						1	1								
DAPHNIA PARVULA						1									
DIAPHANOSOMA LEUCHTENBERGIANUM	1		1												
ILYOCRYPTUS IMM.								1							
LEYDIGIA ACANTHOCERCOIDES					1										
LEYDIGIA QUADRANGULARIS		1							1						
MOINA IMM.			2												
MOINA MINUTA			1												
PLEUROXUS DENTICULATUS		1	1		1		1				1			1	
PLEUROXUS HAMULATUS											1				
SCAPHOLEBERIS KINGI			1		1				1						
SIDA CRYSTALLINA				1											
COPEPODA															
ATTHEYELLA NORDENSKIOLDII										1					
CALANOIDA IMM.			1				1						1		
CYCLOPOIDA IMM.	1	2	5	5	4	4	4	2	2	1	2	1	2	3	2
CYCLOPS BICUSPIDATUS THOMASI						1									
CYCLOPS VARICANS RUBELLUS					1										1
CYCLOPS VERNALIS				1	2					1					
DIAPTOMUS REIGHARDI						1									
ELAPHOIDELLA BIDENS CORONATA	1	1	2	1	1			1				3	1		
ERGASILUS SP.									1						
EUCYCLOPS AGILIS		4							1	1				2	1
EUCYCLOPS SPERATUS									1					1	
HARPACTICOID IMM.	1												2		2
MACROCYCLOPS ALBIDUS		5			1							1			1
MESOCYCLOPS EDAX			1	1		1	1								
NAUPLII	2	4	5	3	4	5	3	3	2	1	4	2	3	4	3
TROPOCYCLOPS PRASINUS				1	2	1					1			2	
ROTIFERA															

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80

Table 13. (Continued)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BDELLOIDEA	1		3	1	1	2	1	2	1		1				1
BRACHIONUS ANGULARIS	2	1	1		1			3		1	1	1	1	1	1
BRACHIONUS BUDAPESTINENSIS	1			1	1										
BRACHIONUS CALYCIFLORUS					1									1	
BRACHIONUS CAUDATUS		1			1										
BRACHIONUS HAVANAENSIS					1										
BRACHIONUS QUADRIDENTATUS			1		1										
CEPHALODELLA SP.		1			1			2		2	2	1	5	1	2
CONOCHILOIDES SP.			1												
CONTRACTED ROTIFERA	3	2	3	1	3	1	1	1	1	1	2	1	2	1	3
EUCHLANIS SP.	1	3	4	2	3	5	1	4	1	3	1	2	2	2	3
FILINIA LONGISETA										1			1		1
HEXARTHRA SP.					1										
KELLICOTTIA BOSTONIENSIS	1					1									
KERATELLA CRASSA		1						1	1						
KERATELLA EARLINAE												1			
LECANE LEONTINA					1										
LECANE SP.			1	2	1	1			1		1	1			
LEPADELLA SP.								1							
MACHROCHAETUS SUBQUADRATUS															1
MONOSTYLA QUADRIDENTATA			1	1											
MONOSTYLA SP.				1		3									
MYTILINA SP.				1											
NOTHOLCA SP.								1	1	1		1		1	
NOTOMMATA SP.				2							1				
PLATYIAS PATULUS			3	1	2		2						1		
PLATYIAS QUADRICORNIS	1	1	1	1	1										
POLYARTHRA SP.		1		1								1			
ROTARIA NEPTUNIA						1									
ROTARIA SP.					1			1						1	
SYNCHAETA SP.		1	2		1	1									
TESTUDINELLA SP.			1	1		2	1						1	1	
TRICHOTRIA SP.	1	1		1	1	1	1	1		1		1	1	1	

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81

The first principal component separated study reaches into three distinct groups based upon organism abundance (figure 35). Compared with other study reaches, Lillards Mill had maximum abundance of Bdelloidea, *Synchaeta*, and *Platyias patulus* (rotifers) while Dement Bridge had maximum abundance of *Bosmina longirostris*, *Bosminopsis* and Cyclopoid copepoids. These two reaches are identified on figure 35 as Group I. Group II sites (Sowell Ford, Halls Mill, and Elk River) either contained a single dominant taxon (Sowell Ford = *Mesocyclops edox*, Elk River = *Chydorus*) or subdominant taxa (Halls Mill = *Platyias patulus* and *Bosmina longirostris*) proportionally more abundant than Group III study reaches. Group III reaches contained *Cephalodella* (negative eigenvectors) with the greatest abundance of this rotifer occurring on the Paint Rock River.

The second principal component showed very strong separation of Dement Bridge from all other reaches (figure 36) based upon presence and abundance of the three major cladoceran taxa (all with negative eigenvectors). Maximum abundance of *Bosminopsis*, *Daphnia ambigua*, and *Daphnia* instars were reported at Dement Bridge. These taxa were not encountered at any other study reach except for a low abundance of *Daphnia ambigua* and *Daphnia* instars at the Elk River reach. Lillards Mill and Halls Mill were the only reaches containing all four major rotifer taxa. A large proportion of the study reaches (Fort Blackmore, Kyles Ford, Copper Creek, Hale Bridge, Click Island, Buchanan Ford, and Fletcher Ford) contained none of the major taxa identified by the second principal component.

Based upon the third principal component (figure 36), Paint Rock River and Halls Mill were separate from other reaches based upon the occurrence of *Branchionus caudatus* at only these two reaches. Those same two

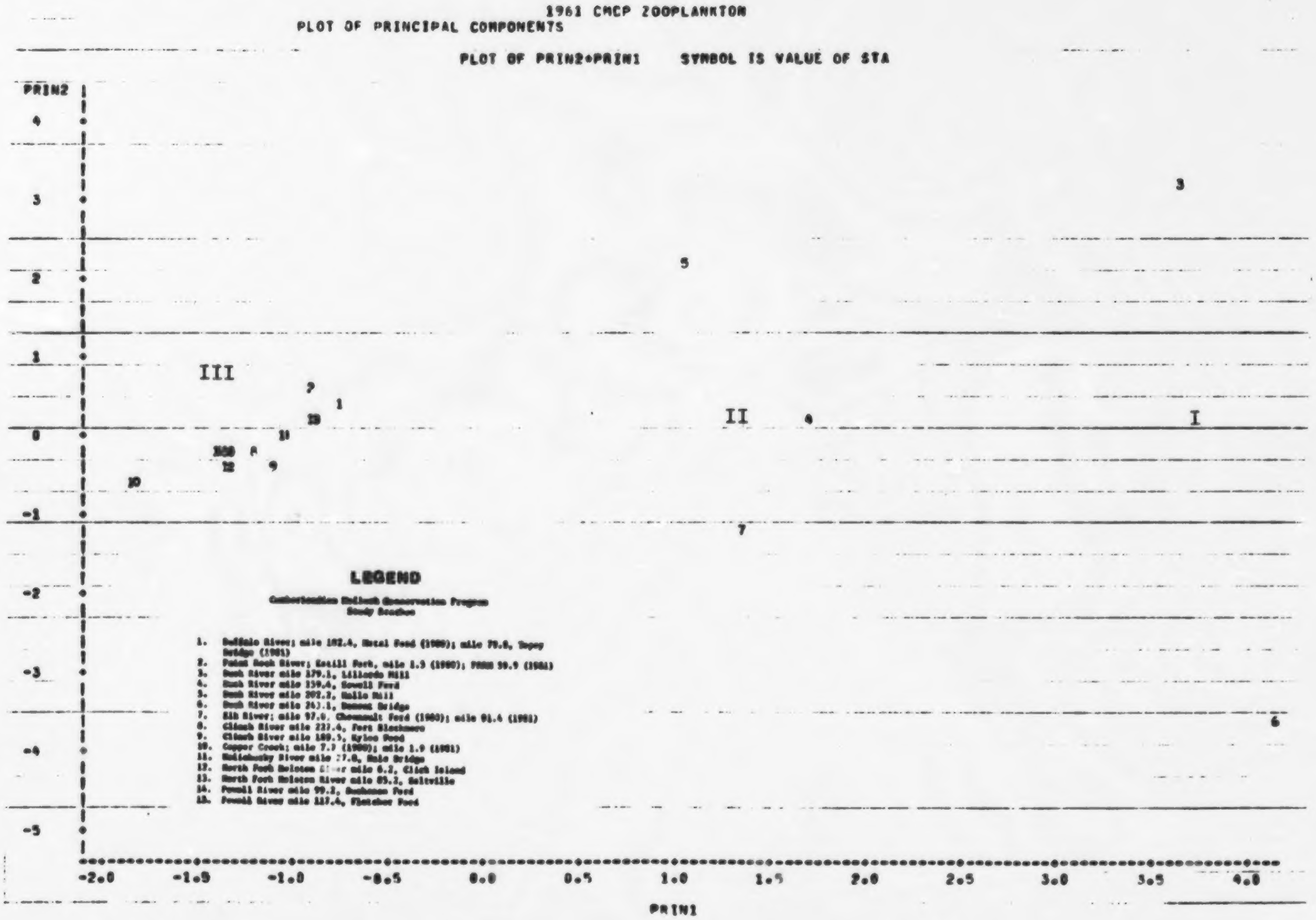

Figure 35. Comparison of Study Reaches Based Upon the First and Second Principal Components of Zooplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program.

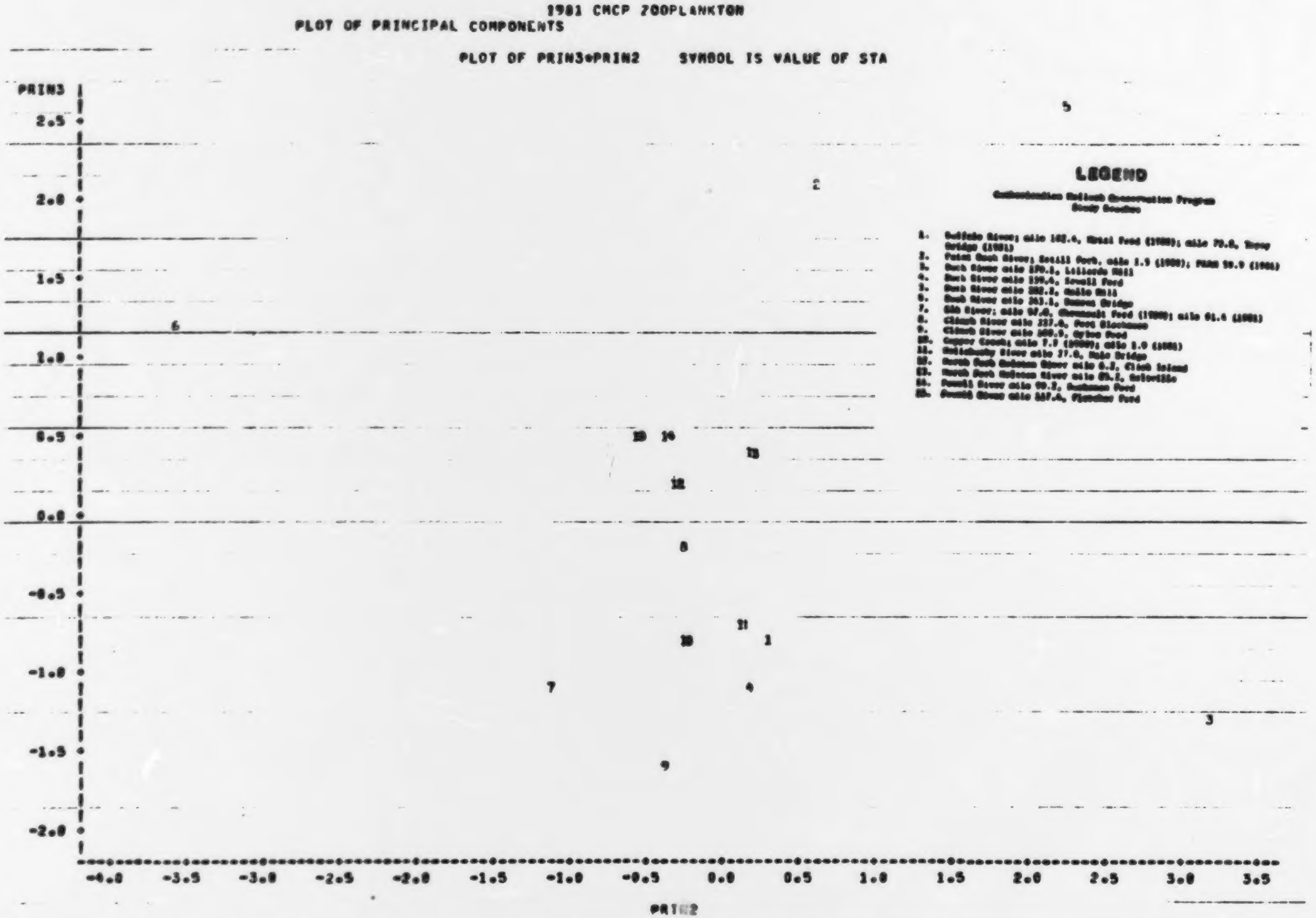

Figure 36. Comparison of Study Reaches Based Upon the Second and Third Principal Components of Zooplankton Data Collected April through September 1981, Cumberlandian Mollusk Conservation Program.

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reaches were especially separate from Lillards Mill and Kyles Ford as they both contained *Trichotria*, *Brachionus caudatus*, and *Cephalodella* which were not reported from either Lillards Mill or Kyles Ford. In addition, Kyles Ford was the only 1981 study reach with complete absence of *Bosmina longirostris*.

Organic Solids

Suspended and organic (= volatile) solids data are provided in appendices G and H. Test results (table 14) failed to show significant differences ($\alpha = 0.05$) between surface and near-bottom depths for each station and year; therefore, depths were combined for further testing and are illustrated in figures 37 and 38 (suspended solids) and 39 and 40 (organic solids).

A statistical summarization of these data (table 15) showed highly significant ($\alpha = 0.01$) location differences based on both suspended and organic solids. In 1980, transported solids were greatest at Fort Blackmore (reach 8) and second greatest at Sowell Ford and Hale Bridge (reaches 4 and 11, respectively). Organic solids were greatest at the same three reaches (8, 4, and 11), but with seven other locations joining the upper statistical ranking: Paint Rock River, Fletcher Ford, Saltville, Kyles Ford, Dement Bridge, Halls Mill, and Lillards Mill.

In 1981, Elk River Mile 91.4 (reach 7) had significantly greater amounts of both suspended and organic solids than all other locations. The second ranking of reaches included a broad group of 9 reaches for suspended solids and 11 reaches for organic solids.

Table 14. T-Test for Depth (Surface and Near Bottom) Differences of Suspended and Volatile Solids at Each Designated Study Reach, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

	Degrees of Freedom*				t-Value†			
Study Reach	Suspended Solids		Volatile Solids		Suspended Solids		Volatile Solids	
	1980	1981	1980	1981	1980	1981	1980	1981
1. Buffalo River								
Metal Ford	9		9		0.793		0.492	
Topsy Bridge		22		22		0.355		0.489
2. Paint Rock River								
Estill Fork	10		10		0.722		0.890	
Mile 60.0		22		22		1.171		1.393
3. Duck River								
Lillards Mill	8	17	8	17	1.321	0.478	0.945	0.641
4. Duck River								
Sowell Ford	10	18	10	18	0.469	0.125	0.600	1.467
5. Duck River								
Halls Mill	9	18	9	18	0.494	0.000	0.517	0.759
6. Duck River								
Dement Bridge	8	18	8	18	0.302	0.261	0.250	0.133
7. Elk River								
Chennault Ford	10		10		1.962		0.542	
Mile 91.4		17		17		0.867		0.326
8. Clinch River								
Fort Blackmore	8	18	10	18	0.460	0.088	0.781	0.820

(Continued)

Table 14. (Continued)

	Degrees of Freedom*				t-Value†			
Study Reach	Suspended Solids		Volatile Solids		Suspended Solids		Volatile Solids	
	1980	1981	1980	1981	1980	1981	1980	1981
9. Clinch River								
Kyles Ford	10	18	10	18	1.165	0.042	0.389	0.149
10. Copper Creek								
Mile 7.7	10		10		0.150		0.000	
Mile 1.9		18		18		0.337		0.318
11. Nolichucky River								
Hale Bridge	9	18	9	18	0.304	1.204	0.058	0.583
12. Holston River (N.F.)								
Click Island	10	18	10	18	0.674	1.226	0.879	0.447
13. Holston River (N.F.)								
Saltville	10	18	10	18	1.446	0.149	0.307	1.037
14. Powell River								
Buchanan Ford	9	18	9	18	0.597	0.022	0.658	0.343
15. Powell River								
Fletcher Ford	10	18	10	18	0.133	0.245	0.000	0.000

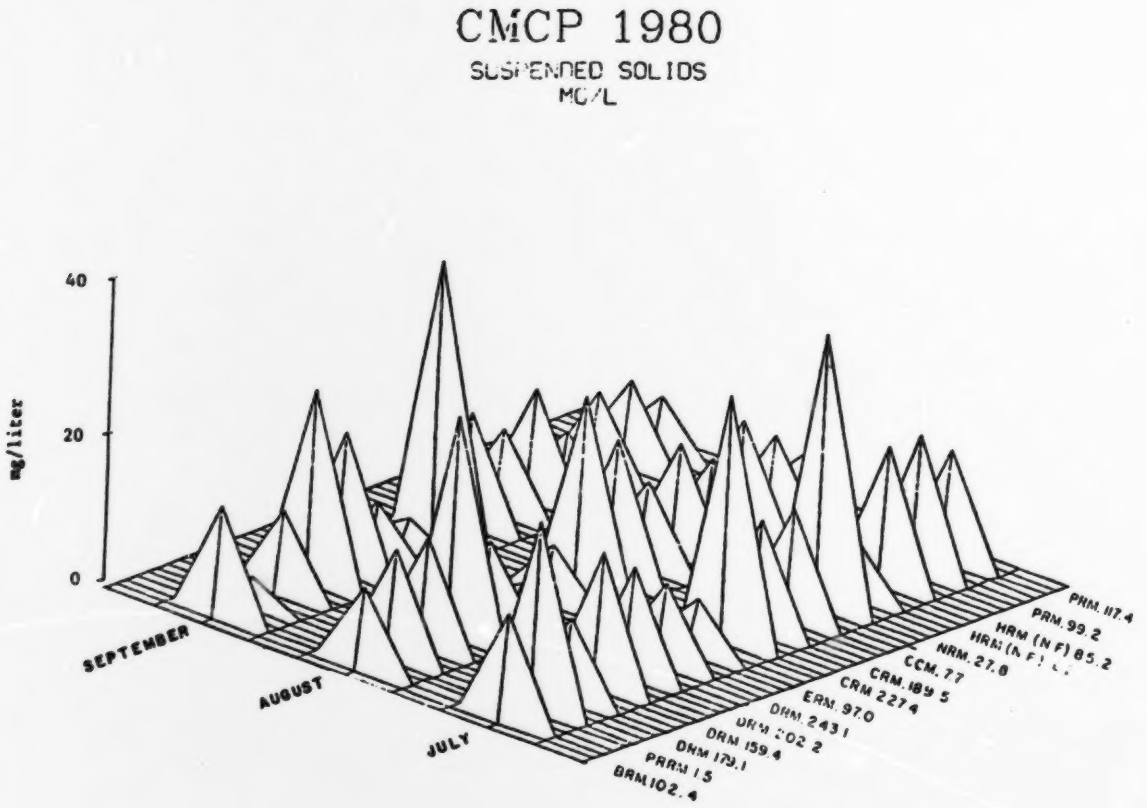
*df = $n_1 + n_2 - 2$

†t-statistic for small sample tests of differences between two means; $\mu_1 = \mu_2$ (Freund, 1973).

Critical values of t-distribution:

$t_{.05}$ [8] = 2.306
$t_{.05}$ [9] = 2.262
$t_{.05}$ [10] = 2.228

$t_{.05}$ [17] = 2.110
$t_{.05}$ [18] = 2.101
$t_{.05}$ [22] = 2.074



CMCP 1980
SUSPENDED SOLIDS
MG/L

Figure 37. Monthly Suspended Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980.

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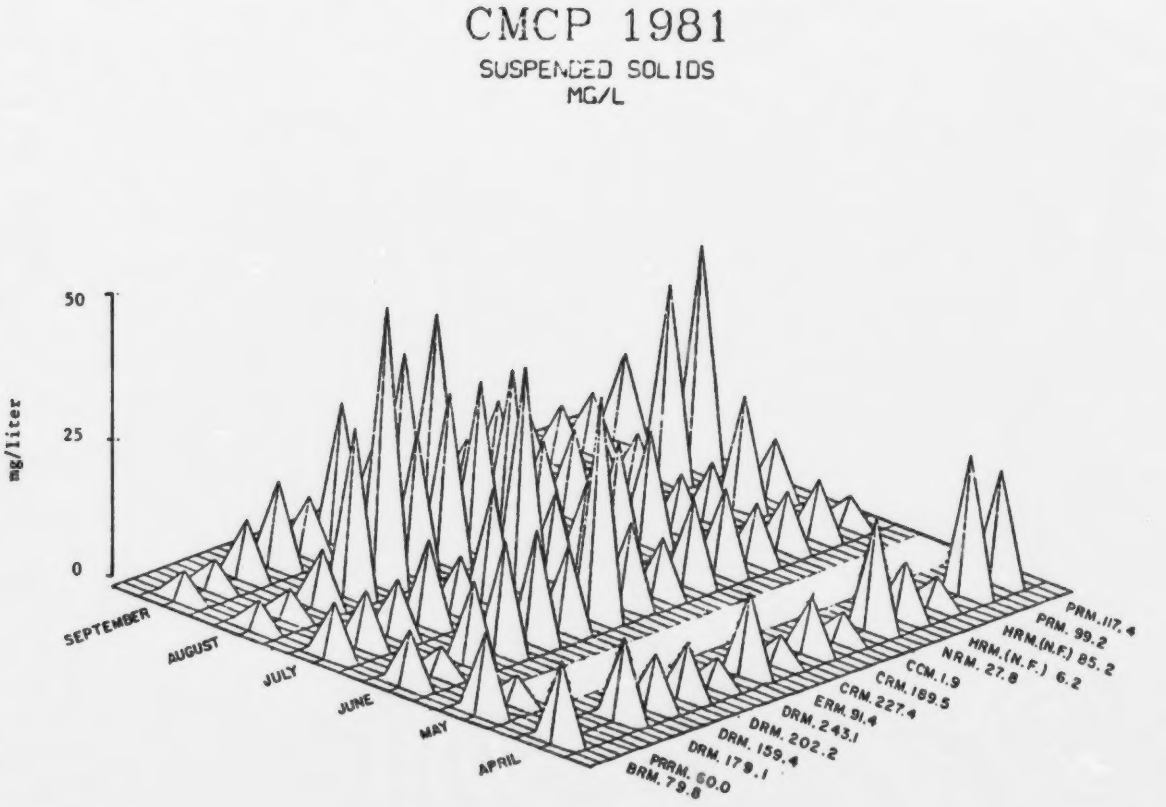

Figure 38. Monthly Suspended Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981.

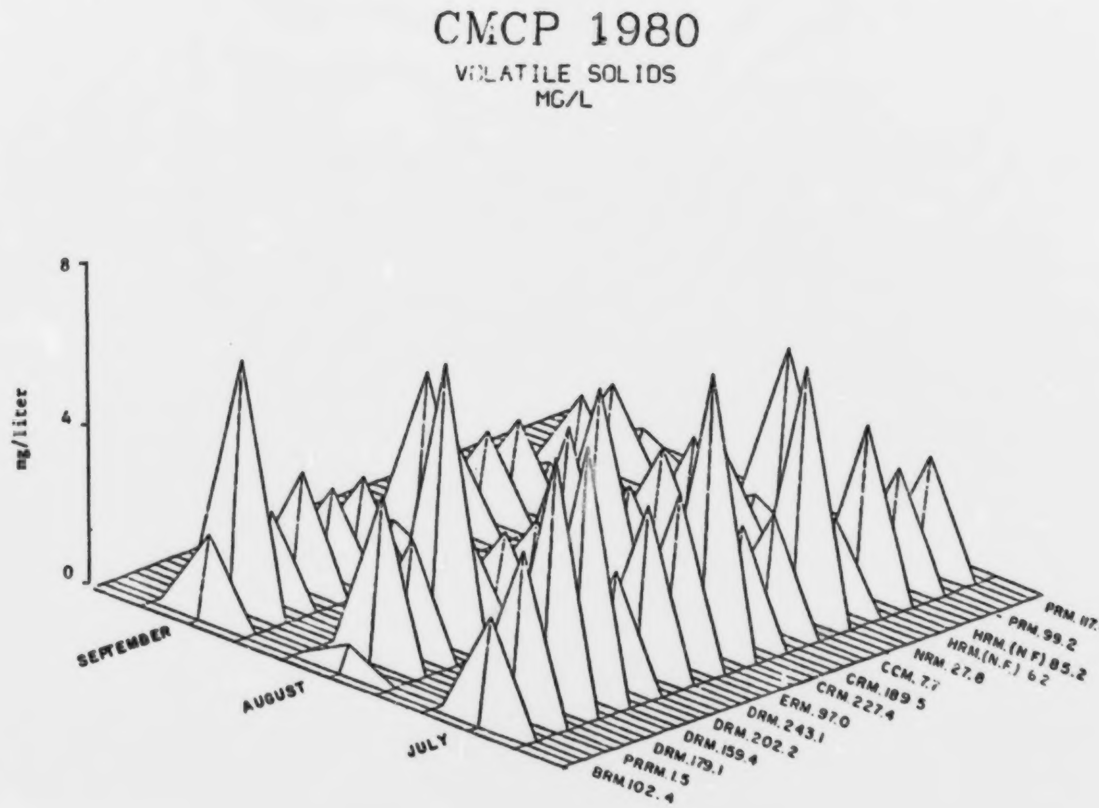

Figure 39. Monthly Volatile Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1980.

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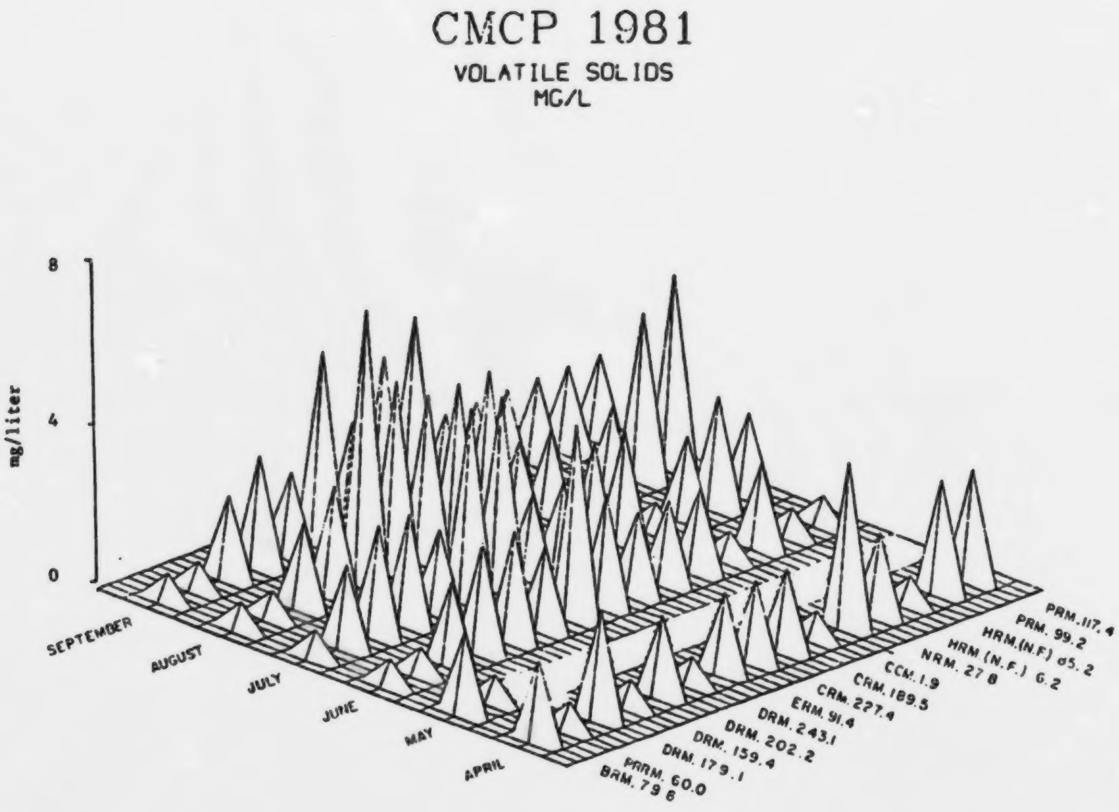


Figure 40. Monthly Volatile Solids Concentrations at Designated Reaches, Cumberlandian Mollusk Conservation Program, 1981.

Table 15. Suspended and Volatile Solids One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Parameter	Year	F-Value*	Degrees of Freedom (Treatment, Error)	Statistically Similar Reaches (α = 0.05).															Range of Means
				Lowest													Highest		
Suspended Solids (mg/l, dry weight)	1980	12.528	(14, 157)	7	6	12	15	3	10	1	13	14	2	5	9	11	4	8	6-31
	1981	10.795	(14, 291)	2	12	13	1	3	10	6	4	8	11	14	15	5	9	7	4-28
Volatile Solids (mg/l)	1980	3.649	(14, 157)	1	7	10	12	14	3	5	6	9	13	15	2	11	4	8	2-5
	1981	5.131	(14, 291)	1	2	12	3	10	13	4	5	6	8	9	11	14	15	7	1-5

*Critical F-values for (treatment, error) degrees of freedom; (a = .05/a = .01):
(14, 157); 1.70/2.09
(14, 291); 1.70/2.09

.All reaches underscored by the same line are similar. Determined by Duncan's new multiple-range test modified for unbalanced sample design (Steele and Torrie, 1960).

Reaches:
1. Buffalo River; Metal Ford (1980), Topsy Bridge (1981)
2. Paint Rock River; Estill Fork (1980), Mile 60 (1981)
3. Duck River; Lillards Mill
4. Duck River; Sowell Ford
5. Duck River; Halls Mill
6. Duck River; Dement Bridge
7. Elk River; Chennault Ford (1980), Mile 91.4 (1981)
8. Clinch River; Fort Blackmore
9. Clinch River; Kyles Ford
10. Copper Creek; Mile 7.7 (1980); Mile 1.9 (1981)
11. Nolichucky River; Hale Bridge
12. North Fork Holston River; Click Island
13. North Fork Holston River; Saltville
14. Powell River; Buchanan Ford
15. Powell River; Fletcher Ford

Lillards Mill (reach 3) ranked in the lowest one-third of the reaches for both parameters, suggesting that high levels of suspended and organic solids (as determined) are not essential to mussel populations. Based on these data, 12 mg/liter suspended and 3 mg/liter organic solids are acceptable levels for selecting tranplant sites.

Periphyton

Unlike transient plankton and suspended solids, organisms comprising the periphyton are attached to a substrate and therefore are present at a location for a relatively longer time. As included in this evaluation, periphyton was attached to the stream bottom at each study reach and is considered part of the benthic community. Very little in the biological literature suggests that periphyton serves as a major food source for mussels, apart from that growing attached to the posterior portion of mussel shells which may become dislodged and ingested (Allen, 1914). However, abundance and composition of the periphyton may indicate conditions favorable to mussel growth.

Abundance--Abundance data for periphyton total numbers and dominant algal groups are provided in appendices I and J, respectively. These data were transformed using a log transformation and statistically tested and ranked (table 16) to show locations with similar periphyton abundance.

In 1980, Estill Fork and Metal Ford) showed the highest (not statistical) total periphyton abundance. Greatest statistical abundance

Table 16. Periphyton One-Way Analysis of Variance and Duncan's New Multiple-Range Test, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Year	Periphyton Group	Degrees of Freedom (Treatment, Error)	F-Value	P >F	Statistically Similar Reaches ($\alpha = 0.05$)*															R^2
					Lowest														Highest	
1980	Total	(14, 75)	4.32	0.0001	12	6	11	7	14	8	10	5	15	4	9	13	3	1	2	0.446
	Chlorophyta	(14, 75)	5.97	0.0001	11	1	6	10	3	5	7	4	12	2	8	13	14	15	9	0.527
	Chrysophyta	(14, 75)	7.79	0.0001	5	12	3	15	14	11	4	9	8	13	6	7	2	10	1	0.593
	Cyanophyta	(14, 75)	4.15	0.0001	12	6	11	9	7	14	10	8	15	5	13	4	3	1	2	0.436
1981	Total	(14, 113)	2.42	0.0054	9	2	5	6	10	8	12	4	13	14	15	1	11	7	3	0.230
	Chlorophyta	(14, 113)	3.44	0.0001	10	1	2	9	6	12	5	4	11	8	15	7	14	3	13	0.299
	Chrysophyta	(14, 113)	3.49	0.0001	5	6	9	4	7	14	15	13	8	12	2	3	10	11	1	0.302
	Cyanophyta	(14, 113)	2.29	0.0084	9	10	5	2	13	14	8	6	1	12	4	15	3	11	7	0.221

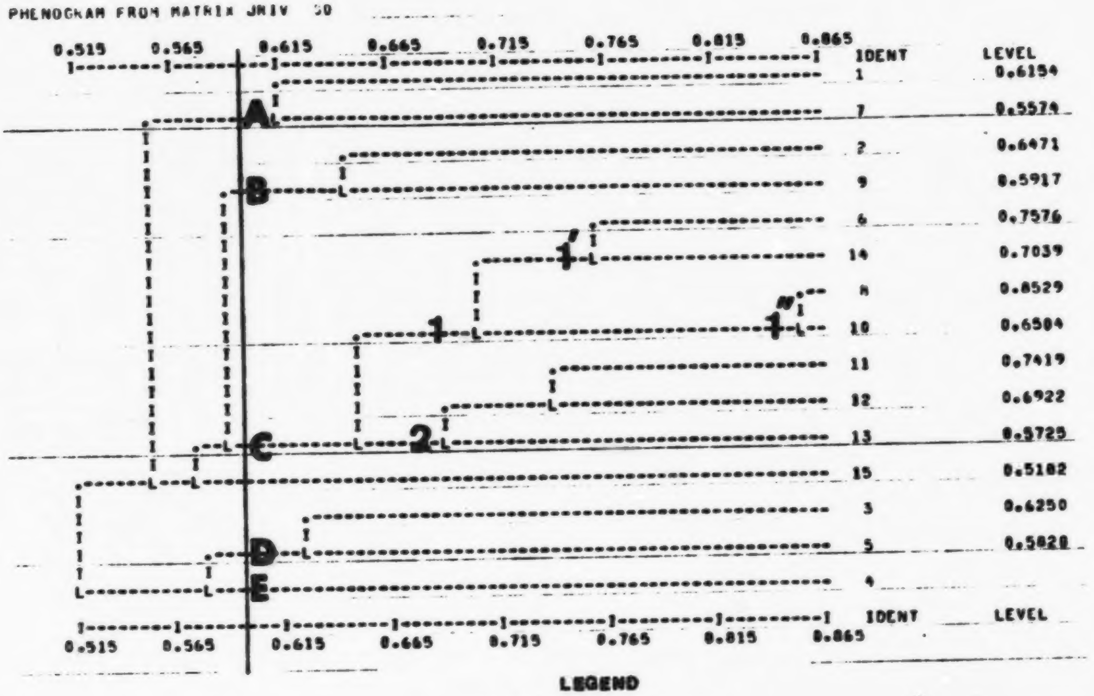
*All reaches underscored by the same line are similar. Rankings are based on log transformed data.

Reaches:
1. Buffalo River; Metal Ford (1980), Topsy Bridge (1981)
2. Paint Rock River; Estill Fork (1980), Mile 60 (1981)
3. Duck River, Lillards Mill
4. Duck River, Sowell Ford
5. Duck River, Halls Mill
6. Duck River, Dement Bridge
7. Elk River; Chennault Ford (1980), Mile 91.4 (1981)
8. Clinch River, Fort Blackmore
9. Clinch River, Kyles Ford
10. Copper Creek; Mile 7.7 (1980), Mile 1.9 (1981)
11. Nolichucky River, Hale Bridge
12. North Fork Holston River, Click Island
13. North Fork Holston River, Saltville
14. Powell River, Buchanan Ford
15. Powell River, Fletcher Ford

occurred at these two reaches and also at Chennault Ford, Buchanan Ford, Fort Blackmore, Copper Creek Mile 7.7, Halls Mill, Fletcher Ford, Sowell Ford, Kyles Ford, Saltville, and Lillards Mill (listed in increasing order of periphyton abundance). In 1981, Lillards Mill demonstrated greatest total periphyton abundance (2,495.4 x 10^3 cells/cm^2) and was statistically ranked with nine other reaches: Fort Blackmore, Click Island, Sowell Ford, Saltville, Buchanan Ford, Fletcher Ford, Topsy Bridge, Hale Bridge, and Elk River Mile 91.4 (again in increasing order of abundance). Therefore, Fort Blackmore, Sowell Ford, Saltville, Buchanan Ford, Fletcher Ford, Elk River, and Lillards Mill consistently ranked as locations with high periphyton total abundance.

Community Structure--Periphyton communities were usually dominated by blue-green algae (Cyanophyta). Notable exceptions (>100 x 10^3 cells/cm^2) occurred at (1) Lillards Mill (Chrysophyta/Chlorophyta, 1981), (2) Kyles Ford (Chlorophyta, 1980), (3) Saltville (Cyanophyta/Chlorophyta, 1981), (4) Buchanan Ford (Cyanophyta/Chlorophyta, 1981), and (5) Topsy Bridge (Cyanophyta/Chrysophyta, 1981). Even where Cyanophyta dominated, blue-green abundance was much reduced in 1981.

Clustering of study reaches based upon the 1980 presence/absence periphyton data is shown in figure 41. Primary cluster C comprised the largest and most similar collection of study reaches which were further clustered into subgroups C_1 (Dement Bridge, Buchanan Ford, Fort Blackmore, Copper Creek) and C_2 (Hale Bridge, Click Island, Saltville). Fort Blackmore and Copper Creek ($C_{1''}$) had the greatest taxonomic similarity (level = 0.8529). These were the only two reaches containing the red algae (Rhodophyta) *Asterocytis* and were unusual as being the only reaches in



LEGEND

Cumberlandian Mollusk Conservation Program
Study Reaches

1. Buffalo River; mile 102.4, Metal Ford (1980); mile 79.8, Topsy Bridge (1981)
2. Paint Rock River; Estill Fork, mile 1.5 (1980); PRRM 39.9 (1981)
3. Duck River mile 179.1, Lillards Mill
4. Duck River mile 139.4, Sowell Ford
5. Duck River mile 282.2, Halls Mill
6. Duck River mile 243.1, [illegible] Bridge
7. Elk River; mile 97.0, [illegible] Ford (1980); mile 91.6 (1981)
8. Clinch River mile 227.6, Fort Blackmore
9. Clinch River mile 189.3, Kyles Ford
10. Copper Creek; mile 7.7 (1980); mile 1.9 (1981)
11. Nolichucky River mile 27.8, Hale Bridge
12. North Fork Holston River mile 6.2, Click Island
13. North Fork Holston River mile 83.2, Saltville
14. Powell River mile 99.2, Buchanan Ford
15. Powell River mile 117.6, Fletcher Ford

Figure 41. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Periphyton Taxa Collected at Study Reaches, July Through September 1980, Cumberlandian Mollusk Conservation Program.

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addition to Hale Bridge and Click Island (C_2) with the Pyrrophyte *Glenodinium*. Clusters A, B, D, and E were each composed of no more than two reaches with lower degree of similarity than those reaches in cluster C. Distribution of taxa among the 15 designated study reaches is shown in table 17.

Analysis of study reaches based upon PCA showed the first three principal components respectively accounted for 21 percent, 14 percent, and 13 percent, or together about 48 percent of the total variability within the data. Important variates for the first three principal components were as follows.

Component 1	Component 2	Component 3
Gyrosigma	*Melosira*	*Epithemia*
Diatoma	*Rhoicosphenia*	*Oedogonium*
Oedogonium	*Epithemia*	*Mougeotia*
Rhizoclonium	*Spirogyra*	*Cladophora*
Cladophora	*Ulothrix*	*Anabaena*
Anacystis	*green #1*	*Merismopedia*
Calothrix	*Anabaena*	*Oscillatoria* (spiral)
	Anacystis	

The first principal component grouped study reaches based upon abundance and occurrence of the important taxa listed above. As shown in figure 42, Lillards Mill, Sowell Ford, Halls Mill, Metal Ford, Click Island, Hale Bridge, and Elk River were grouped as study reaches with low periphyton abundance and containing fewer than four of the seven important taxa. Lillards Mill only contained one (*Gyrosigma*) of these taxa which had a very low level of abundance (100 cells/cm^2). Dement Bridge, nearest Normandy Dam, was the only Duck River study reach containing a majority (six) of the seven important taxa, although abundances were low.

Table 17. Periphyton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, July through September 1980. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.)

TAXA	STUDY REACH														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHLOROPHYTA															
ANKISTRODESMUS						1		1	1	1	1				
CARTERIA													1		
CHLAMYDOMONAS		1			1	1			1	1	1	1	1	1	1
CHLORELLA									1		1		1		
CHLOROGONIUM											1				
CLADOPHORA							1		1	1			2	1	2
CLOSTERIUM			1	2											
COSMARIUM	1	2		1		1			1	1	1	1	1	1	
CRUCIGENIA		1							1						
DICTYOSPHAERIUM									1		1				
EUASTRUM									1						
GOLENKINIA									1						
GONGROSIRA	2	2	1	1	1	1	1	1	2	1			1	1	2
HYALOTHECA			1												
MOUGEOTIA		1		1		1	1	2		1	1	1	1	1	
OEDOGONIUM	1	2				1	2	2	1	2	1	2	2	2	
PROTOCOCCUS	1	2	1	2	2	2	2	2	2	2	1	1	1	1	1
PTEROMONAS				1			1						1		
RHIZOCLONIUM		1		1		2	2	2	2	1		1	2	2	1
SCENEDESMUS		1	1		1	1	1	2	1	1	1	2	1	1	
SCHROEDERIA			1		1										
SPIROGYRA		2	1	1											
SPONDYLOSIUM				1		1	1					1			
STAURASTRUM	1	1													
STIGEOCLONIUM	2	2	2	2	2	2	2	1	1	2	2	1	1	1	1
TETRAEDRON								1	1						
ULOTHRIX		1				1								1	1
UNID GREEN #1		1													
CHRYSOPHYTA															
ACHNANTHES	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1
CHAETOCEROS										1					
COCCONEIS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CYCLOTELLA											1				
CYMBELLA	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2
DIATOMA		1				1	2	2	1	2				1	
DINOBRYON								1		1		1	1		
EPITHEMIA		2				1	1								
FRAGILARIA								1	1	2				1	
GOMPHONEMA	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
GYROSIGMA	1		1	2		1		1		1	1	2		1	1

98

Table 17. (Continued)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MALLOMONAS															1
MELOSIRA	2		2	2	2	2	2	2	2	2	2	1	1	1	2
MERIDION											1				
NAVICULA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
NITZSCHIA	1	1	1	2	1	2	2	2	1	2	2	1	2	1	2
PINNULARIA										1					
PLEUROSIGMA															1
RHOICOSPHENIA	1					2	2	2		2	2	2	2	1	1
STEPHANODISCUS	1				1	1	1		1	1					
SURIRELLA		1	1	1	1			1	1	1				1	
SYNEDRA	2	2	2	2	2	2	2	2	1	2	2	1	2	1	1
SYNURA			1												
CRYPTOPHYTA															
CHROOMONAS											1		1	1	
CRYPTOMONAS		1	1						1		1		1		
CYANOPHYTA															
ANABAENA		1	1												
ANACYSTIS		1				1		2	1	2	1	1	1	1	2
APHANOCAPSA		1													
APHANOTHECE									1						
CALOTHRIX		1		1	1	1		1		2			1	2	2
CHROOCOCCUS										1					
DACTYLOCOCCOPSIS				1							2				
LEPTOCHAETE			1				1			1					
LYNGBYA	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
MERISMOPEDIA											1				2
OSCILLATORIA	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
OSCILLATORIA (SPIRAL)															1
UNID BLUE-GREEN #1				1	1										
EUGLENOPHYTA															
EUGLENA				1				1		2	1	1			
TRACHELOMONAS				1				2		2	1	1	2		
PYRROPHYTA															
GLENODINIUM								1		1	1	1			
GYMNODINIUM											1				
RHODOPHYTA															
ASTEROCYTIS								1		1					

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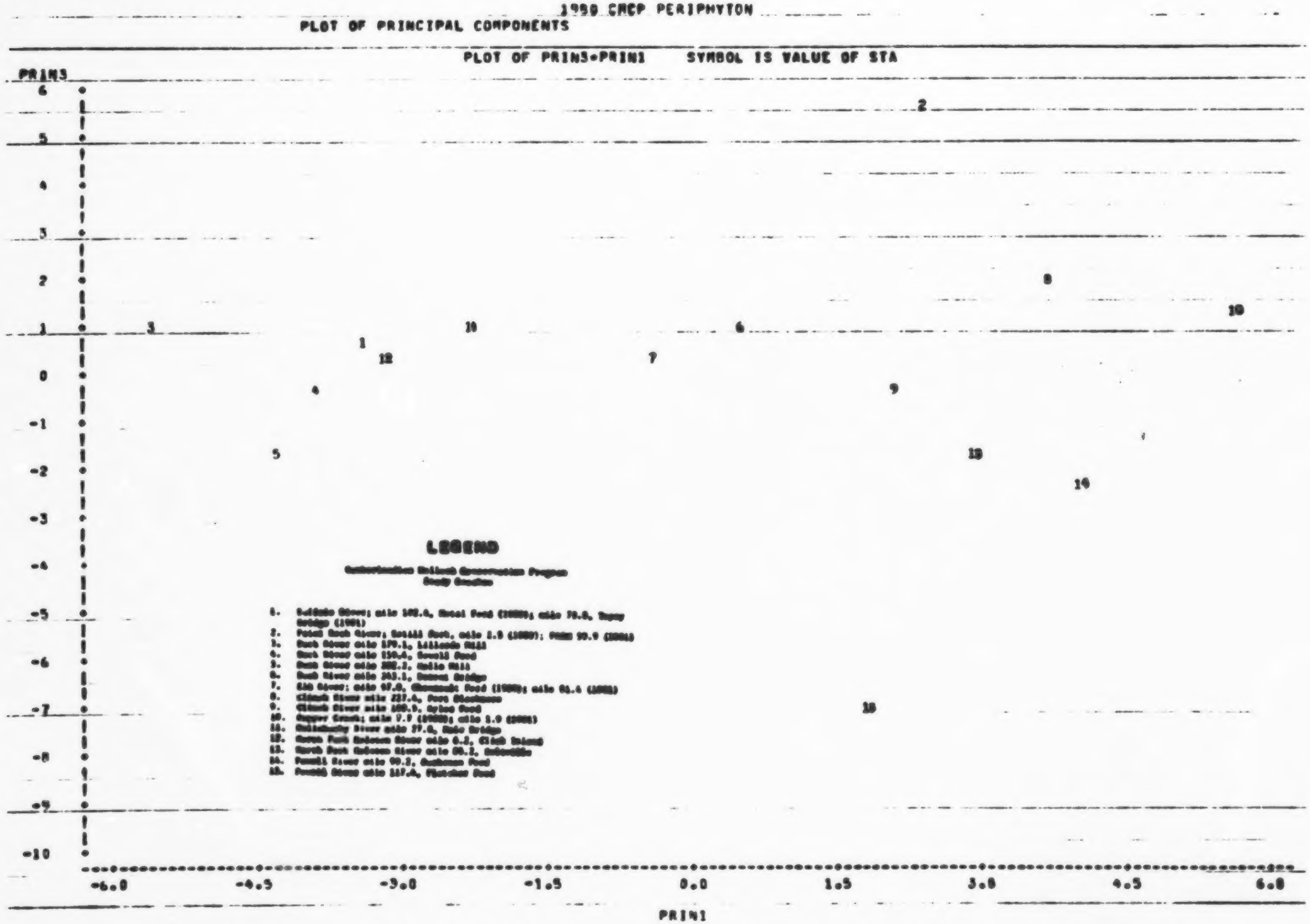

Figure 42. Comparison of Study Reaches Based Upon the First and Third Principal Components of Periphyton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.

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The second principal component separated Estill Fork (Paint Rock River) from all other reaches (figure 43) based upon (1) the simultaneous occurrence of *Epithemia*, *Spirogyra*, *Ulothrix*, an unidentified chlorophyte, *Anabaena*, and *Anacystis* (loading negatively) and (2) the absence of *Melosira* and *Rhoicosphenia* (loading positively). *Melosira* occurred at all other reaches. *Rhoicosphenia* and *Anacystis* were identified at most study reaches, except for Metal Ford and the three downstream Duck River reaches, Lillards Mill, Halls Mill, and Sowell Ford.

The third component separated Estill Fork and Fletcher Ford from each other and from other study reaches (figure 43) based upon occurrence of *Epithemia*, *Oedogonium*, *Mougeotia*, and *Anabaena* at Estill Fork (all absent at Fletcher Ford) and occurrence of *Cladophora*, *Merismopedia*, and *Oscillatoria* (spiral) at Fletcher Ford (all absent at Estill Fork). *Oscillatoria* (spiral) was present only at Fletcher Ford, while *Anabaena* was present only at Estill Fork and Lillards Mill. *Oedogonium* occurred at all locations except for the three downstream Duck River reaches and Fletcher Ford.

In 1981 study reaches were grouped into six primary clusters based upon the presence/absence distribution of periphyton taxa (figure 44). The two most similar reaches, Elk River and Fort Blackmore (level = 0.8571), were part the second major subgrouping of reaches consisting of Buchanan Ford, Copper Creek, and Kyles Ford contained in primary cluster D. Dement Bridge (D_1) was the only other site to join cluster D (level = 0.6788). Of the other Duck River reaches, Sowell Ford and Halls Mill were most similar (cluster C), while Lillards Mill was grouped with Click Island and Fletcher Ford (cluster B). Topsy Bridge (A) and Paint Rock River (F) were very different from each other and from all other study reaches. The distribution of taxa among study reaches (table 18) indicates Topsy Bridge and Paint

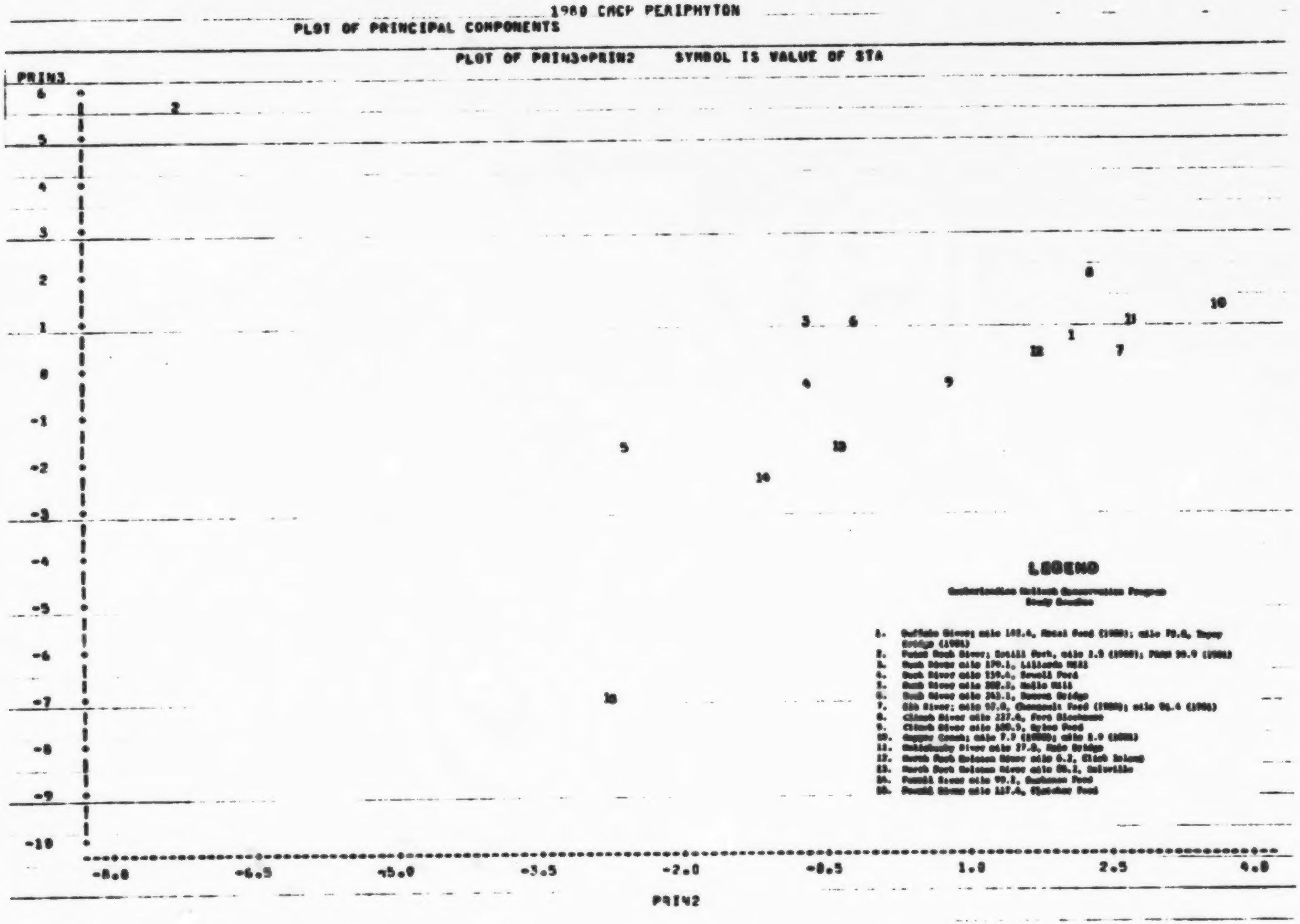
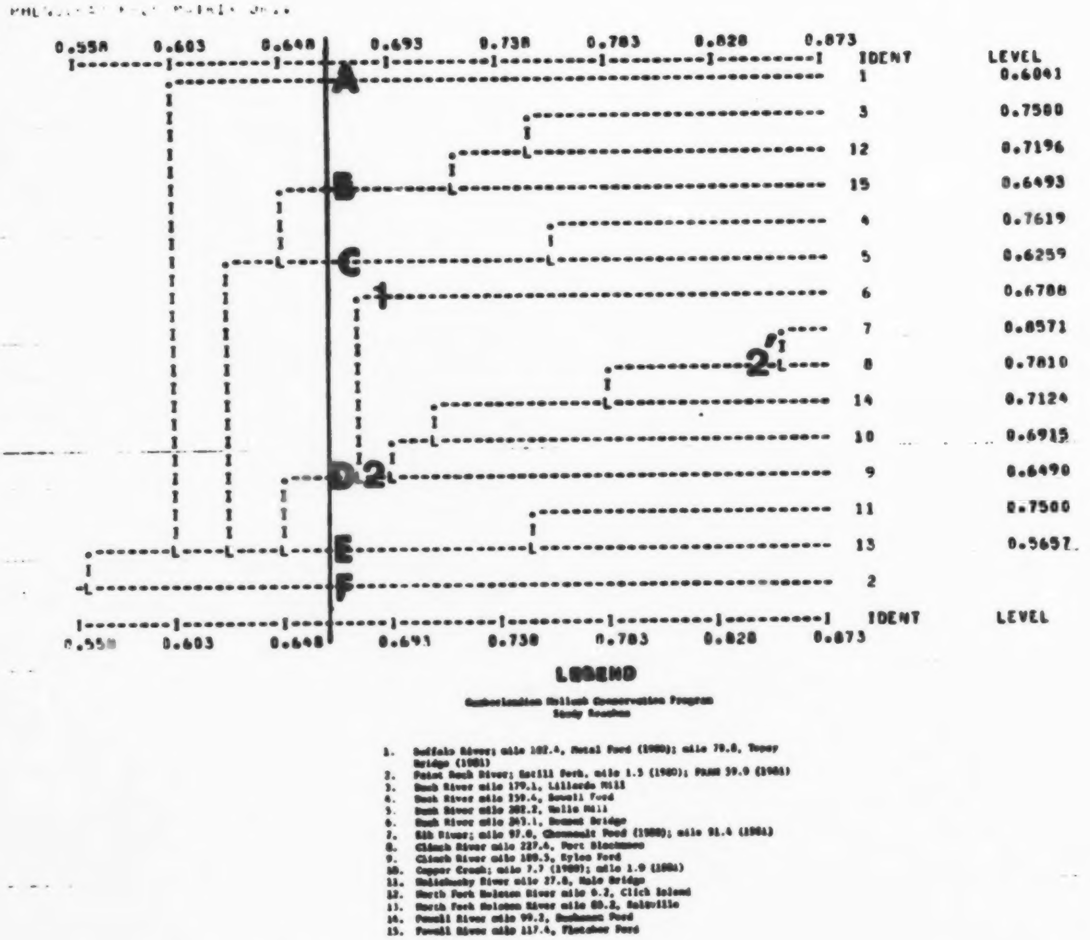


Figure 43. Comparison of Study Reaches Based Upon the Second and Third Principal Components of Periphyton Data Collected July through September 1980, Cumberlandian Mollusk Conservation Program.



LEGEND

Cumberlandian Mollusk Conservation Program
Study Reaches

1. Buffalo River; mile 102.4, Metal Ford (1980); mile 79.8, Topsy Bridge (1981)
2. Paint Rock River; Estill Fork, mile 1.5 (1980); PRRM 39.9 (1981)
3. Duck River mile 179.1, Lillards Mill
4. Duck River mile 150.4, [illegible] Ford
5. Duck River mile 202.2, [illegible] Mill
6. Duck River mile 243.1, [illegible] Bridge
7. Elk River; mile 97.0, [illegible] Ford (1980); mile 91.4 (1981)
8. Clinch River mile 227.6, Fort Blackmore
9. Clinch River mile 189.5, Kyles Ford
10. Copper Creek; mile 7.7 (1980); mile 1.9 (1981)
11. Nolichucky River mile 27.8, Hale Bridge
12. North Fork Holston River mile 6.2, Click Island
13. North Fork Holston River mile 80.2, [illegible]
14. Powell River mile 99.2, Buchanan Ford
15. Powell River mile 117.4, Fletcher Ford

Figure 44. Phenogram from Q-Mode Cluster Analysis of Presence-Absence Data on Periphyton Taxa Collected at Study Reaches, June Through September 1981, Cumberlandian Mollusk Conservation Program.

Table 18. Periphyton Taxa Collected at Fifteen Study Reaches, Cumberlandian Mollusk Conservation Program, June through September 1981. (Data Refer to Number of Sampling Dates on Which Taxon was Collected.)

	STUDY REACH														
TAXA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHLOROPHYTA															
CHARACIUM			1												
CHLAMYDOMONAS					1										
CHLOROGONIUM											1				
CLADOPHORA											1		1		1
CLOSTERIUM															1
COSMARIUM	1			1		1			3	2	1			2	1
GEMINELLA													1		
GONGROSIRA		1	2		2		2	3		1	3	1	3	1	2
KIRCHNERIELLA							1								
MOUGEOTIA		2	1	2			1								
OEDOGONIUM		2		1	1	1	1	1		1				1	
PROTOCOCCUS		2	2	1	1	1	2	3	2		1	3	2	1	2
PROTODERMA	1	1													
RHIZOCLONIUM	1	2	3		1	1	2	1	1	1	1		3	2	3
SCENEDESMUS	1					1	1	1		1	1		1		
SPIROGYRA		1													
STAURASTRUM					1										
STIGEOCLONIUM	2	1	3	3	3	3	3	3	2	3	2	1	3	3	3
ULOTHRIX		1	1						1				1		
CHRYSOPHYTA															
ACHNANTHES	3	2	2	1	1	1	2	2	2	3	3	3	3	2	3
CHAETOCEROS						1									
COCCONEIS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CYCLOTELLA									1						
CYMATOPLEURA	1										1				
CYMBELLA	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
DIATOMA			1			1	2	3	1	2		1		2	3
EPITHEMIA	1	3	1							1		1			
FRAGILARIA								1							
GOMPHONEMA	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
GYROSIGMA			1	1	1	1						1			2
MALLOMONAS								2							
MELOSIRA	3	1	3	2	3	3	3	3	3	3	3	3	2	3	2
MERIDION		1						1							
NAVICULA	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
NITZSCHIA	3	1	2	2	1	2	3	1	2	3	3	3			2
RHIZOSOLENIA			1			1		1							1
RHOICOSPHENIA	1		2	1	1		1	1	1		1	1		2	1
STEPHANODISCUS	1	2	2	1								1			1
SURIRELLA			1					1							

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Table 18. (Continued)

TAXA	STUDY REACH 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SYNEDRA	2	3	2	3	3	3	3	3	3	3	3	2	1	1	2
SYNURA			1												
CYANOPHYTA															
ANABAENA							1								
ANACYSTIS				1	1										
CALOTHRIX		1													1
DACTYLOCOCCOPSIS			1			2									
LYNGBYA	2	2	3	3	3	3	3	3	2	2	3	3	3	3	3
MERISMOPEDIA		2									1	2			
OSCILLATORIA	3	3	1	2	2		2	2	2	1	3	2	2	3	2
SPIRULINA							1								
EUGLENOPHYTA															
EUGLENA			1						1	1					
TRACHELOMONAS									1						

Rock River were the only reaches to contain Protoderma. Taxa occurring only at Paint Rock River and a very limited number of other reaches (≤2) included Spirogyra, Meridion, Calothrix, and Merismopedia. Cymatopleura only occurred at Topsy Bridge and Hale Bridge.

PCA analysis showed the first three components respectively accounted for 22 percent, 14 percent, and 12 percent, or together about 47 percent of the total variability. Important variates for the first three components were as follows.

Component 1	Component 2	Component 3
Acnanthes	Stephanodiscus	Nitzschia
Epithemia	Diatoma	Rhoicosphenia
Stephanodiscus	Rhizoclonium	Meridon
Protoderma	Stigeoclonium	Diatoma
Gongrosira	Gongrosira	Rhizosolenia
Mougeotia	Protococcus	Fragilaria
Spirogyra	Rhizosolenia	Mallomonas
Ulothrix	Cladophora	Anacystis
Calothrix	Anacystis	
Merismopedia		

The first principal component separated Paint Rock River from all other study reaches (figure 45). This study reach was unique in having maximum abundance of 9 of 10 important genera. Protoderma was most abundant at Topsy Bridge, occurring only there and at the Paint Rock River study reach. Calothrix and Spirogyra occurred only at the Paint Rock River.

The second component separated study reaches into three groups: (I) Topsy Bridge, Sowell Ford; (II) Paint Rock River, Halls Mill, Dement Bridge, Kyles Ford, Cooper Creek, Click Island; and (III) Hale Bridge,

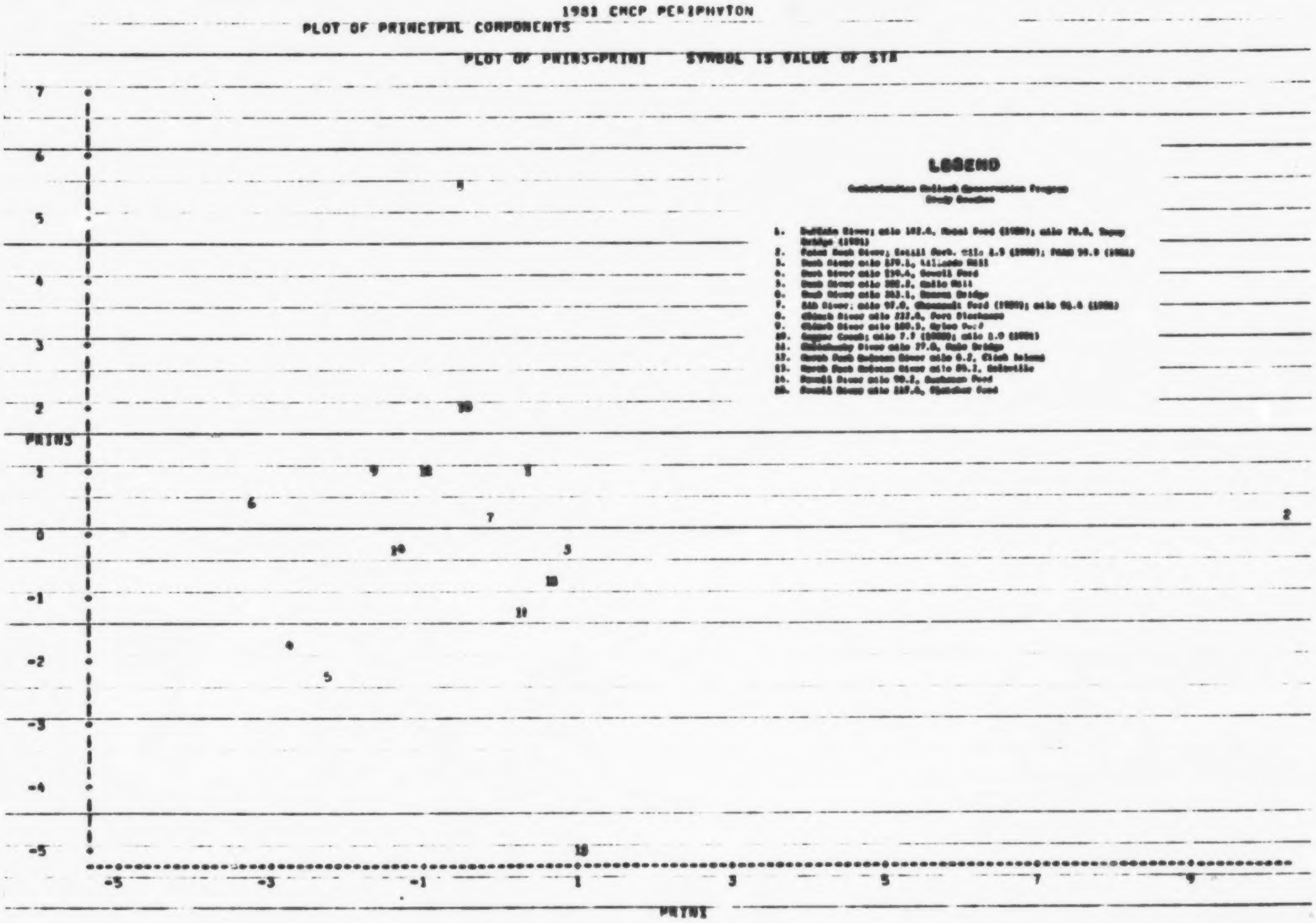

Figure 45. Comparison of Study Reaches Based Upon the First and Third Principal Components of Periphyton Data Collected June through September 1981, Cumberlandian Mollusk Conservation Program.

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Lillards Mill, Elk River, Buchanan Ford, Fletcher Ford, Saltville, Fort Blackmore (figure 46). Group differences were based largely on number of important taxa occurring at each reach as group I reaches contained three taxa, group II reaches contained four taxa, and group III reaches contained 5-8 taxa. Stigeoclonium was the only important periphyton genus to occur at all 15 study reaches.

The third component (figure 46) separated Fort Blackmore and Saltville from each other and from all other sites based upon the occurrence of seven out of eight important taxa at Fort Blackmore. None of the important taxa occurred at Saltville.

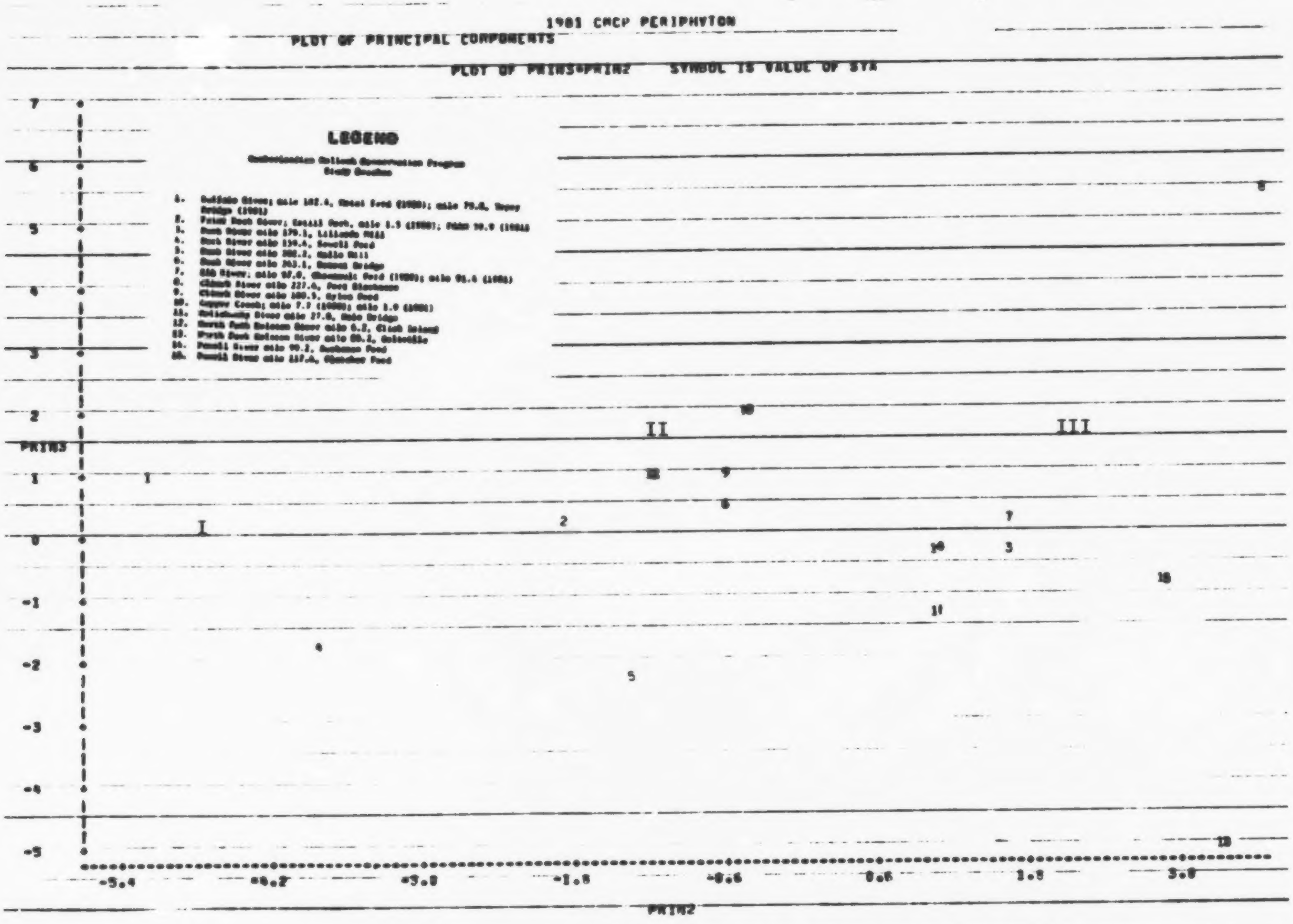

Figure 46. Comparison of Study Reaches Based Upon the Second and Third Principal Components of Periphyton Data Collected June through September 1981, Cumberlandian Mollusk Conservation Program.

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SUMMARY AND CONCLUSIONS

AQUATIC MACROPHYTES

Abundance--Submersed/floating-leaved and emergent vegetation at the study reaches likely improve mussel habitat by stabilization of the channel and substrate and attract fish species that may be the host for glochidia. Three study reaches (Dement Bridge, Copper Creek, and Elk River) consistently ranked low in ratio of vegetative cover. The Buffalo River study reach also was low in emergent and composite vegetative cover rankings. Two sites, Hale Bridge and Click Island, were somewhat atypical due to a high ratio of emergent or submersed/floating-leaved vegetation.

Community Structure--Cluster analysis using emergent and submersed/floating-leaved species along river reaches generally produced macrophyte communities characteristic of the physiographic provinces (e.g., Ridge and Valley or Interior Low Plateau) in which they occurred. Exceptions were Copper Creek, Saltville, and Paint Rock River. The tributary nature of Copper Creek and the headwater characteristics of the North Fork of the Holston River above Saltville possibly account for these "anomalies." The Paint Rock River had several plant species unique to that system which accounts for the low level of similarity with the other two main groupings.

Analyses by river system also indicated strong differences between the Paint Rock River the other major clusters. The Clinch, North Fork of the Holston, Powell, Duck, and Nolichucky Rivers comprised one cluster with the remaining major cluster consisting of the Buffalo River, Elk River, and Copper Creek.

PLANKTON, ORGANIC SOLIDS, AND PERIPHYTON

Abundance--Identification of sites with statistically greater levels of biological productivity was based upon the phytoplankton, zooplankton, and periphyton communities. Higher levels of organism abundance were considered important because the site with the greatest number of *Conradilla caelata* and large numbers of other mussels (Lillards Mill) always ranked as highly productive and because productive sites would more than meet mussel nutritional requirements. Sites with significantly greater community productivity are listed as follows.

Phytoplankton	Zooplankton	Periphyton
Lillards Mill	Lillards Mill	Lillards Mill
Dement Bridge	Dement Bridge	Sowell Ford
Fort Blackmore	Hale Bridge	Elk River
Hale Bridge		Fort Blackmore
		Hale Bridge
		Saltville
		Buchanan Ford
		Fletcher Ford

Sowell Ford, Fort Blackmore, and Hale Bridge also demonstrated greater levels of organic solids; however, solids data were inconclusive and indicated that, as measured, high organic solids may not correlate well with nutritional requirements.

Overall conclusion based upon plankton and periphyton abundance is that two sites on the Duck River (Lillards Mill and Dement Bridge), one on the Clinch River (Fort Blackmore), and one on the Nolichucky River (Hale Bridge) are nutritionally best suited for mussel transplants. Sites with less potential, but more likely with an adequate food source, include Sowell Ford, Elk River, Kyles Ford, Saltville, and Fletcher Ford.

Community Structure--Conclusions based upon community structure are difficult to draw because of the overall large number of planktonic and periphytic taxa represented in the analyses and because of the absence of adequate information relating mussel occurrence with taxonomic presence/absence patterns. However, contrasts among study reaches have merit because community structure data should indicate broad ecological similarities among study reaches or river systems. The following conclusions are based on principal component and cluster analyses, but primarily on PCA since this data management and reduction technique provides the most definitive information about important taxonomic associations.

Contrasts of study reaches based upon floristic (phytoplankton and periphyton) assembledges were similar to analyses of aquatic macrophyton data in that study reach similarities generally corresponded to physiographic provinces. Except for the Hale Bridge study reach on the Nolichucky River which tended to group with reaches in the Interior Low Plateau, reaches in the Ridge and Valley province grouped together (were similar based upon taxonomic associations). This separation of Ridge and Valley Province reaches from reaches in other physiographic provinces was especially obvious in the analyses which are summarized below.

Community	Year	Analysis	Unique Associations (PCA)*
Phytoplankton	1980	Cluster PCA_1	*Coelastrum*, *Golenkinia*, *Oocystis*, and *Dyctosphaerium* (chlorophytes) and *Merismopedia* (cyanophyte) important at Paint Rock (Estill Fork), Duck, and Nolichucky River reaches; poorly represented at Ridge and Valley Province reaches.
Phytoplankton	1981	Cluster PCA_1	*Pandorina*, *Trachlemonas*, *Anacystis*, *Aphanozomenon*, and *Spiruling* well represented at Interior Low Plateau reaches (especially Lillards Mill and Dement Bridge); but absent at Ridge and Valley Province reaches.
		PCA_2	*Cosmarium* present at all Ridge and Valley Province reaches except Fletcher Ford; poorly represented at Interior Low Plateau Province reaches. *Spermatozoopsis* present at Low Interior Plateau Province reaches; absent at Ridge and Valley Province reaches.
Periphyton	1980	Cluster PCA_1	*Oedogonium* and *Anacystis* abundant and/or well represented at Ridge and Valley Province reaches and at Dement Bridge and Estill Fork. *Cladophora* represented only at Ridge and Valley Province reaches.
Periphyton	1981	Cluster	

In 1981 zooplankton assembledges also demonstrated the clustering of Ridge and Valley Province study reaches (with the Paint Rock River) in analysis of the first principal component based upon the almost total absence of *Synchaeta*, *Platyias patulus*, and *Mesocyclops edax* at those reaches and the presence of *Cephalodella*. Apart from Ridge and Valley

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*Utilizes major taxa (variates) identified in first (PCA_1), second (PCA_2), or third (PCA_3) principal component.

Province reaches, Lillards Mill and Dement Bridge, in the Interior Low Plateau Province, were most alike having maximum abundance of taxa identified by the first principal component: Bdelloidea, Synchaeta sp., Platyias patulus (Lillards Mill) and Euchlanis, Bosmina longirostris, Bosminopsis, and cyclopoid copepodids (Dement Bridge).

Study reaches wih the greatest overall diversity for each year sampled (total taxa, combined communities and sampling months) were Estill Fork (125 taxa) and Hale Bridge (126 taxa) in 1980 and Lillards Mill (96 taxa) and Dement Bridge (91 taxa) in 1981. Phytoplankton diversity was greatest at Lillards Mill, Hale Bridge, Dement Bridge, and Estill Fork. Zooplankton also was well represented at Estill Fork. Reaches with the lowest number of combined taxa were Metal Ford (1980), Topsy Bridge (1981), Cooper Creek (1981), and Buchanan Ford (1981).

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Appendix A. Aquatic Macrophytes Along River Reaches Being Investigated as Cumberlandian Mollusk Conservation Program Transplant Sites.

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
Buffalo River - Topsy Bridge 7/15/80; 10/1/81	Podostemum ceratophyllum	Common	Justicia americana	Common	BRM 105.1 to 98.1 = 7 miles 80.4 to 74.8 = 5.6 miles
	Porella pinnata	Scattered	Leersia oryzoides	Scattered	
	Vallisneria americana	Rare	Onoclea sensibilis	Rare	
			Orontium aquaticum	Rare	
			Saururus cernuus	Scattered	
Paint Rock River, Mile 60 - Estill Fork and Paint Rock River 7/11/80 *Broken down by drainage (EF vs PRR) since so different	A. Estill Fork				
	Chara sp.	Scattered	Justicia americana	Abundant	EFM 2.2 to EFM 0 = 2.2 miles
	Leptodictyum riparium	Common	Leersia oryzoides	Scattered	
	Myriophyllum heterophyllum	Rare	Scirpus validus	Rare	
	Porella pinnata	Scattered			
	Potamogeton amplifolius	Scattered			
	Potamogeton crispus	Rare			
	Potamogeton foliosus	Scattered			

Continued

Appendix A. (Continued)

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
	B. Paint Rock River				
	Chara sp.	Rare	*Justicia americana*	Common	PRRM 60 to PRRM 54 6 miles
	Leptodictyum riparium	Scattered	*Nuphar luteum*	Scattered	
	Myriophyllum heterophyllum	Rare			
	Porella pinnata	Scattered			
	Potamogeton amplifolius	Rare			
	Potamogeton crispus	Rare			
	Potamogeton foliosus	Rare			
Duck River - Lillards Mill 7/16/80	*Elodea canadensis*	Rare	*Justicia americana*	Common	DRM 179.2 to 172.2 7 miles
	Fissidens fontanus	Scattered	*Leersia oryzoides*	Scattered	
	Heteranthera dubia	Scattered	*Saururus cernuus*	Scattered	
	Porella pinnata	Scattered			
	Potamogeton foliosus	Rare			
	Potamogeton nodosus	Scattered			

Continued

Appendix A. (Continued)

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
Duck River - Sowells Ford 7/17/80	*Fissidens fontanus*	Scattered	*Justicia americana*	Common	DRM 172.1 to 156.3 15.8 miles
	Heteranthera dubia	Scattered	*Leersia oryzoides*	Scattered	
	Podostemum ceratophyllum	Scattered			
	Porella pinnata	Scattered			
	Potamogeton nodosus	Rare			
Duck River - Halls Mill Dam 7/30/80	*Elodea canadensis*	Scattered	*Justicia americana*	Common	DRM 210.3 to 192.1 18.2 miles
	Fissidens fontanus	Scattered	*Leersia oryzoides*	Scattered	
	Podostemum ceratophyllum	Scattered	*Saururus cernuus*	Rare	
	Porella pinnata	Scattered	*Scirpus americanus*	Rare	
	Potamogeton nodosus	Scattered			
Duck River - Dement Bridge 7/31/80	*Fissidens fontanus*	Scattered	*Decodon verticillata*	Rare	DRM 248.2 to 235.4 12.8 miles
	Leptodictyum riparium	Rare	*Justicia americana*	Common	
	Podostemum ceratophyllum	Scattered	*Leersia oryzoides*	Common	
	Porella pinnata	Scattered	*Nasturtium officinale*	Rare	
			Saururus cernuus	Scattered	

Continued

Appendix A. (Continued)

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
Elk River - Chennault Ford 7/29/80	*Callitriche heterophylla*	Rare	*Heteranthera reniformis*	Rare	ERM 104.3 to 88.3 16.0 miles
	Fissidens fontanus	Rare	*Justicia americana*	Scattered	
	Podostemum ceratophyllum	Scattered	*Leersia oryzoides*	Scattered	
	Porella pinnata	Scattered	*Nasturtium officinale*	Rare	
Clinch River - Fort Blackmore 9/9/80	*Elodea canadensis*	Rare	*Justicia americana*	Common	CRM
	Heteranthera dubia	Scattered	*Leersia oryzoides*	Scattered	CRM 234.0
	Leptodictyum riparium	Rare	*Phalaris arundinacea*	Scattered	to 220.9
	Porella pinnata	Scattered	*Scirpus americana*	Rare	13.1 miles
	Potamogeton nodosus	Rare	*Scirpus validus*	Rare	
	Potamogeton pectinatus	Rare			
Clinch River - Kyles Ford 8/13/80	*Heteranthera dubia*	Scattered	*Eleocharis palustris*	Scattered	CRM 195.5 to 181.4 14.1 miles
	Lemanea sp.	Rare	*Justicia americana*	Common	
	Leptodictyum riparium	Rare	*Leersia oryzoides*	Scattered	
	Porella pinnata	Scattered	*Saururus cernuus*	Scattered	
	Potamogeton nodosus	Scattered	*Scirpus americanus*	Rare	
	Vallisneria americana	Scattered			

Continued

Appendix A. (Continued)

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
Copper Creek	*Porella pinnata*	Scattered	*Justicia americana*	Common	Surveyed from road access points
			Leersia oryzoides	Scattered	
Nolichucky River - Hales Bridge 8/12/80	*Elodea canadensis*	Rare	*Eleocharis palustris*	Scattered	NRM 36.7 to 20.9 15.8 miles
	Eurhynchium riparioides	Rare	*Justicia americana*	Common	
	Fissidens fontanus	Rare	*Leersia oryzoides*	Common	
	Lemanea sp.	Rare	*Scirpus americana*	Rare	
	Podostemum ceratophyllum	Common	*Scirpus validus*	Rare	
	Porella pinnata	Scattered			
North Fork Holston River - Click Island 9/11/80	*Elodea canadensis*	Rare	*Eleocharis palustris*	Scattered	NFHRM 11.4 to 0.5 10.9 miles
	Heteranthera dubia	Scattered	*Justicia americana*	Scattered	
	Porella pinnata	Rare	*Leersia oryzoides*	Scattered	
	Potamogeton nodosus	Common	*Sagittaria* sp.	Rare	
	Potamogeton pectinatus	Scattered	*Saururus cernuus*	Scattered	
	Vallisneria americana	Abundant	*Scirpus validus*	Rare	

Continued

Appendix A. (Continued)

Site (River Reach)/ Date Surveyed	Submersed Macrophytes/Floating Leaved		Emergent Macrophytes		Miles/Surveyed
North Fork Holston River - Saltville 9/10/80	*Ceratophyllum demersum*	Rare	*Iris psendo-acorus*	Scattered	NFHRM 88.6 to 80.0 8.6 miles
	Chara sp.	Rare	*Justicia americana*	Common	
	Heteranthera dubia	Scattered	*Leersia oryzoides*	Common	
	Leptodictyum riparium	Rare	*Scirpus americanus*	Rare	
	Porella pinnata	Scattered	*Scirpus validus*	Scattered	
	Potamogeton foliosus	Scattered			
	Potamogeton nodosus	Scattered			
Powell River - Fletcher Ford 8/13/80	*Lemanea* sp.	Rare	*Justicia americana*	Common	DRM 120.3 to 106.8 13.5 miles
	Porella pinnata	Scattered	*Leersia oryzoides*	Scattered	
	Potamogeton nodosus	Scattered	*Nasturtium officinale*	Rare	
	Potamogeton pectinatus	Scattered	*Saururus cernuus*	Common	
			Scirpus americanus	Rare	
Powell River - Buchanan Ford 8/14/80	*Porella pinnata*	Scattered	*Eleocharis palustris*	Scattered	PRM 106.9 to 95.1 11.8 miles
	Potamogeton nodosus	Rare	*Justicia americana*	Common	
	Potamogeton pectinatus	Rare	*Leersia oryzoides*	Scattered	
			Saururus cernuus	Common	
			Scirpus americanus	Rare	

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Appendix B. Growth Form and Species Percentages at Cumberlandian Mollusk Conservation Program Study Reaches.

	Growth Form					Total
Reach	Emergent	%	Submersed/Floating-Leaved	%	Woody %	Percentage
Buffalo River - Topsy Bridge	*Justicia americana*	0.3	*Podostemum ceratophyllum*	2.2	—	2.5
Paint Rock River - Mile 60	*Justicia americana*	19.5	*Leptodictyum riparium*	2.4	3.1	28.6
	Leersia oryzoides	3.6	*Potamogeton crispus*	<0.1		
		23.1	*Potamogeton foliosus*	<0.1		
				2.4		
Duck River - Lillards Mill	*Justicia americana*	4.7	*Potamogeton nodosus*	9.7	1.7	21.8
	Leersia oryzoides	5.7				
		10.4				
Duck River - Sowell Ford	*Justicia americana*	5.5	*Fissidens fontanus*	0.6	0.2	11.7
			Heteranthera dubia	0.2		
			Podostemum ceratophyllum	5.2		
				6.0		
Duck River - Halls Mill	*Justicia americana*	6.6	*Elodea canadensis*	0.4	1.1	12.4
	Justicia americana & *Leersia oryzoides*	4.0	*Fissidens fontanus*	0.3		
		10.6	*Podostemum ceratophyllum*	<0.1		
				0.7		
Duck River - Dement Bridge	*Axenopus furcatus* & *Polygonum* sp.	1.1	————		1.8	3.2
	Justicia americana	0.1				
	Nasturtium officinale	0.1				
	Polygonum sp.	0.1				
		1.4				
Elk River - Mile 91.4	*Justicia americana*	0.5	————		—	1.0
	Polygonum sp.	0.5				
		1.0				

(Continued)

Appendix B. (Continued)

Reach	Growth Form Emergent	%	Submersed/Floating-Leaved	%	Woody %	Total Percentage
Clinch River - Fort Blackmore	Justicia americana	19.3	Elodea canadensis	<0.1	—	19.3
			Heteranthera dubia	<0.1		
				0.0		
Clinch River - Kyles Ford	Justicia americana	13.9	Heteranthera dubia	0.9	—	16.0
	Justicia americana & Saururus cernuus	0.5	Potamogeton crispus	<0.1		
			Potamogeton nodosus	<0.1		
	Saururus cernuus	0.7	Vallisneria americana	<0.1		
		15.1		0.9		
Copper Creek - Mile 1.9	Justicia americana	1.3	—		—	1.3
Nolichucky River - Hale Bridge	Justicia americana	40.2	Elodea canadensis	<0.1	2.0	44.0
				0.0		
	Justicia americana & Leersia oryzoides	1.6				
	Leersia oryzoides & Ludwigia decurrens	0.2				
		42.0				
North Fork Holston River - Click Island	Justicia americana	0.8	Elodea canadensis	<0.1	0.9	47.7
	Leersia oryzoides	3.7	Heteranthera dubia	1.0		
	Sagittaria sp.	<0.1	Potamogeton nodosus	12.4		
	Saururus cernuus	0.1	Potamogeton pectinatus	2.3		
		3.6	Vallisneria americana	27.5		
				43.2		
North Fork Holston River - Saltville	Justicia americana	22.7	—		—	23.0
	Justicia americana & Leersia oryzoides	0.3				
		23.0				

(Continued)

Appendix B. (Continued)

Reach	Growth Form					Total Percentage
	Emergent	%	Submersed/Floating-Leaved	%	Woody %	
Powell River - Buchanan Ford	Justicia americana	9.2	Potamogeton nodosus	0.1	—	13.0
	Justicia americana & Saururus cernuus	2.0				
	Justicia americana & Scirpus americana	0.3				
	Saururus cernuus	1.4				
		12.9				
Powell River - Fletcher Ford	Justicia americana	15.8	Potamogeton nodosus	0.8	—	17.2
	Leersia oryzoides	0.6				
		16.4				

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Appendix C. Total Phytoplankton Abundance (no/l x 10^3), Cumberland Mollusk Conservation Program, 1980 and 1981.

			1980				1981						
Reach	Depth*	Replicate	July	Aug	Sept	$\bar{X}$	April	May	June	July	Aug	Sept	$\bar{X}$
1. Buffalo River	NB	1	224.2	28.0	79.4		152.6	352.4	174.6	60.3	28.6	88.9	
Metal Ford (1980)	NB	2	52.9	15.6	130.2		333.2	263.5	79.4	66.7	63.5	136.5	
Topsy Bridge (1981)	NS	1	252.2	124.6	101.6		93.4	276.2	79.4	76.2	54.0	44.5	
	NS	2	102.8	15.6	117.3		117.5	308.0	63.5	54.0	28.6	101.6	
		$\bar{X}$	158.0	46.0	107.1	103.7	174.2	300.0	99.2	64.3	43.7	92.9	129.0
2. Paint Rock River	NB	1	1,273.6	1,046.3	1,689.1		77.9	133.4	50.8	38.1	73.0	31.8	
Estill Fork (1980)	NB	2	1,650.4	3,008.1	2,152.7		68.5	79.4	31.8	54.0	79.4	28.6	
Mile 60.0 (1981)	NS	1	1,656.7	1,778.1	819.2		65.4	228.6	47.6	57.2	38.1	12.7	
	NS	2	1,040.1	2,217.2	1,920.9		49.8	92.1	41.3	174.6	31.8	25.4	
		$\bar{X}$	1,405.2	2,012.4	1,645.5	1,687.7	65.4	133.4	42.9	81.0	55.6	24.6	67.1
3. Duck River	NB	1	5,524.2	249.1	-†		54.0	NS‡†	772.3	3,181.4	396.9	1,231.9	
Lillards Mill	NB	2	2,759.0	152.6	-		79.4		803.4	3,292.5	546.1	939.8	
	NS	1	3,546.9	87.2	-		127.0		694.4	3,746.5	288.9	990.6	
	NS	2	8,588.4	161.9	-		120.7		650.8	2,797.2	435.0	892.2	
		$\bar{X}$	5,104.6	162.7	-	2,633.7	95.3		730.2	3,254.4	416.7	1,013.6	1,102.1
4. Duck River	NB	1	298.9	224.2	57.2		79.4	NS	622.8	-	117.5	317.5	
Sowell Ford	NB	2	476.4	146.4	155.6		69.9		523.2	-	174.6	279.4	
	NS	1	710.0	193.1	31.8		406.4		563.6	-	85.7	222.3	
	NS	2	1,124.2	214.9	38.1		177.8		604.1	-	66.7	209.6	
		$\bar{X}$	652.4	194.7	70.7	305.9	183.4		578.4	-	111.1	257.2	282.5
5. Duck River	NB	1	439.1	155.7	22.2		140.1	NS	105.9	209.6	88.9	82.6	
Halls Mill	NB	2	158.8	59.2	41.3		140.1		224.2	130.2	82.6	104.8	
	NS	1	96.5	96.5	117.5		196.2		124.6	142.9	76.2	66.7	
	NS	2	411.1	601.0	406.4		149.5		37.4	200.0	41.3	88.9	
		$\bar{X}$	276.4	228.1	121.9	208.8	156.5		123.0	170.7	52.3	85.8	117.6
6. Duck River	NB	1	2,762.1	2,793.3	6,731.0		815.9	NS	1,363.9	904.9	2,540.0	2,454.3	
Dement Bridge	NB	2	4,437.5	3,852.0	10,490.2		1,002.7		1,438.7	1,393.8	2,597.2	1,768.5	
	NS	1	6,355.7	2,606.4	9,563.1		962.2		1,482.3	3,057.8	2,765.4	3,660.8	
	NS	2	2,818.2	1,603.7	5,454.7		1,170.9		1,731.4	2,730.5	2,438.4	2,803.6	
		$\bar{X}$	4,093.4	2,713.9	8,059.8	4,955.7	987.9		1,504.1	2,021.8	2,585.3	2,671.8	1,954.2

Appendix C. (Continued)

Reach	Depth*	Replicate	1980 July	1980 Aug	1980 Sept	1980 X̄	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 X
7. Elk River	NB	1	249.1	105.9	-		193.7	NS	183.7	108.0	-	28.6	
Chennault Ford (1980)	NB	2	342.5	171.3	-		168.3		255.4	123.8	-	38.1	
Mile 91.4 (1981)	NS	1	289.6	196.2	-		442.2		130.8	114.3	-	22.2	
	NS	2	311.4	205.5	-		451.5		208.6	69.9	-	41.3	
		X̄	298.2	169.7	-	233.9	313.9		194.6	104.0	-	32.6	161.3
8. Clinch River	NB	1	1,756.6	241.3	285.8		593.7	NS	1,606.6	142.9	82.6	57.2	
Fort Blackmore	NB	2	2,226.7	349.3	342.9		635.0		1,451.0	108.0	60.3	82.6	
	NS	1	1,308.1	177.8	336.6		766.0		2,155.8	120.7	79.4	136.5	
	NS	2	1,295.4	508.0	438.2		439.1		1,530.4	142.9	76.2	66.7	
		X̄	1,646.7	319.1	350.9	772.2	608.5		1,686.0	128.6	74.6	85.8	516.7
9. Clinch River	NB	1	362.0	374.7	308.3		549.3	NS	1,098.6	89.0	47.6	104.8	
Kyles Ford	NB	2	387.4	489.0	283.4		752.5		876.3	44.5	47.6	88.9	
	NS	1	450.9	628.7	289.6		435.0		1,054.1	34.9	57.2	85.7	
	NS	2	381.0	489.0	395.5		587.4		1,393.8	63.5	38.1	63.5	
		X̄	395.3	495.4	319.2	403.3	581.1		1,105.7	58.0	47.6	85.7	375.6
10. Copper Creek	NB	1	247.7	323.9	489.0		548.1	NS	174.6	63.5	44.5	104.8	
Mile 7.7	NB	2	273.1	222.3	444.5		822.1		412.8	47.6	47.6	146.1	
Mile 1.9	NS	1	437.5	336.6	466.7		713.1		149.2	54.0	54.0	57.2	
	NS	2	235.0	203.2	501.7		585.4		139.7	44.5	54.0	54.0	
		X̄	298.3	271.5	475.5	348.4	667.2		219.1	52.4	50.0	90.5	215.8
11. Nolichucky River	NB	1	140.1	4,406.9	1,158.9		302.1	NS	616.0	215.9	184.2	219.1	
Hale Bridge	NB	2	292.7	6,140.5	952.5		380.0		723.9	279.4	174.6	139.7	
	NS	1	404.8	5,683.3	1,381.1		339.4		349.3	352.4	295.3	133.4	
	NS	2	242.9	7,112.0	1,092.2		295.8		549.3	254.0	241.3	146.1	
		X̄	270.1	5,835.7	1,146.2	2,417.3	329.2		559.6	275.4	223.9	159.6	309.6
12. Holston River (N.F.)	NB	1	292.1	165.1	434.0		882.7	NS	127.0	76.2	44.5	63.5	
Click Island	NB	2	368.3	317.5	292.1		625.5		54.0	111.1	38.1	69.9	
	NS	1	355.6	603.3	320.7		351.9		76.2	111.1	34.9	292.1	
	NS	2	330.2	520.7	682.6		711.2		98.4	120.7	47.6	38.1	
		X̄	336.6	401.7	432.4	390.2	642.8		88.9	104.8	41.3	115.9	198.7

128

Appendix C. (Continued)

Reach	Depth*	Replicate	1980 July	Aug	Sept	$\bar{X}$	1981 April	May	June	July	Aug	Sept	$\bar{X}$
13. Holston River (N.F.)	NB	1	233.6	1,403.4	112.1		327.0	NS	63.5	142.9	34.9	50.8	
Saltville	NB	2	124.6	1,066.8	208.6		283.4		79.4	184.2	95.3	69.9	
	NS	1	46.7	1,270.0	233.6		246.0		63.5	85.7	38.1	41.3	
	NS	2	90.3	1,079.5	308.3		280.3		66.7	79.4	31.8	69.9	
		$\bar{X}$	123.8	1,204.9	215.7	514.8	261.7		68.3	123.1	50.0	58.0	112.2
14. Powell River	NB	1	419.1	444.5	277.2		479.6	NS	130.2	41.3	57.2	120.7	
Buchanan Ford	NB	2	342.9	406.4	308.3		495.1		158.8	28.6	-	123.8	
	NS	1	355.6	514.4	379.9		429.7		155.6	47.6	50.8	82.6	
	NS	2	285.8	774.7	336.3		407.9		203.2	31.8	73.0	85.7	
		$\bar{X}$	350.9	535.0	325.4	403.8	453.1		162.0	37.3	60.3	103.2	168.6
15. Powell River	NB	1	400.1	457.2	862.6		495.1	NS	196.9	54.0	38.1	92.1	
Fletcher Ford	NB	2	304.8	311.2	856.4		401.7		193.7	25.4	34.9	79.4	
	NS	1	311.2	400.1	535.6		432.9		279.4	31.8	47.6	95.3	
	NS	2	425.5	266.7	650.6		579.2		266.7	34.9	41.3	82.6	
		$\bar{X}$	360.4	358.8	726.3	481.8	477.2		234.2	36.5	40.5	87.4	175.2

*NB = Near bottom
NS = Near surface
†Sample lost or not processed

‡No survey conducted

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Appendix D. Phytoplankton Abundance (no./ℓ x 10^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

					1980					1981				
Reach	Phytoplankton Groups	Depths*	Replicate	July	Aug	Sept	$\bar{X}$	April	May	June	July	Aug	Sept	$\bar{X}$
1. Buffalo River Metal Ford (1980) Topsy Bridge (1981)	Chlorophyta	NB	1	18.7	12.5	0.0		18.7	0.0	0.0	3.2	0.0	25.4	
			2	3.1	3.1	6.4		112.1	0.0	0.0	0.0	3.2	88.9	
		NS	1	21.8	9.3	22.2		3.1	0.0	12.7	3.2	0.0	0.0	
			2	18.7	3.1	3.2		31.1	0.0	0.0	0.0	0.0	50.8	
			$\bar{X}$	15.6	7.0	8.0	10.2	41.3	0.0	3.2	1.6	0.8	41.3	14.7
	Chrysophyta	NB	1	68.5	12.5	22.2		127.7	339.0	73.0	57.2	28.6	63.5	
			2	46.7	9.3	69.9		218.0	260.3	79.4	66.7	60.3	47.6	
		NS	1	71.6	15.6	19.1		90.3	266.7	63.5	73.0	54.0	44.5	
			2	77.9	12.5	60.3		137.0	308.0	63.5	54.0	28.6	50.8	
			$\bar{X}$	66.2	12.5	42.9	40.5	143.3	293.5	38.1	62.7	42.9	51.6	105.3
	Cryptophyta	NB	1	9.3	0.0	3.2		3.1	0.0	0.0	0.0	0.0	0.0	
			2	3.1	3.1	0.0		3.1	0.0	0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	
			2	6.2	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	
			$\bar{X}$	4.7	0.8	0.8	2.1	1.6	0.0	0.0	0.0	0.0	0.0	0.3
	Cyanophyta	NB	1	124.6	0.0	54.0		3.1	12.7	101.6	0.0	0.0	0.0	
			2	0.0	0.0	50.8		0.0	3.2	0.0	0.0	0.0	0.0	
		NS	1	155.7	99.7	50.8		0.0	9.5	3.2	0.0	0.0	0.0	
			2	0.0	0.0	50.8		3.1	0.0	0.0	0.0	0.0	0.0	
			$\bar{X}$	70.1	24.9	51.6	48.9	1.6	6.4	26.2	0.0	0.0	0.0	5.7
	Euglenophyta	NB	1	3.1	3.1	0.0		0.0	0.0	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0	0.0	0.0	0.0	0.0	0.0	
		NS	1	3.1	0.0	9.5		0.0	0.0	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0	0.0	0.0	0.0	0.0	0.0	
			$\bar{X}$	1.6	0.8	4.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980 July	Aug	Sept	X̄	1981 April	May	June	July	Aug	Sept	X̄
2. Paint Rock River Estill Fork (1980) Mile 60.0 (1981)	Chlorophyta	NB	1	21.8	137.0	104.8		3.1	0.0	0.0	0.0	47.6	0.0	
			2	99.7	99.7	136.5		0.0	0.0	0.0	0.0	54.0	0.0	
		NS	1	81.0	62.3	127.0		0.0	6.4	0.0	0.0	12.7	0.0	
			2	87.2	236.7	88.9		3.1	0.0	0.0	3.2	0.0	12.7	
			X̄	72.4	133.9	114.3	106.9	1.6	1.6	0.0	0.8	28.6	3.2	6.0
	Chrysophyta	NB	1	68.5	71.6	320.7		74.7	54.0	50.8	38.1	19.1	31.8	
			2	74.7	171.3	266.7		68.5	79.4	31.8	54.0	19.1	28.6	
		NS	1	59.2	99.7	304.8		49.8	76.2	41.3	57.2	12.7	12.7	
			2	18.7	105.9	473.1		46.7	88.9	41.3	44.5	25.4	12.7	
			X̄	55.3	112.1	341.3	169.6	59.9	74.6	41.3	48.5	19.1	21.5	44.1
	Cryptophyta	NB	1	115.2	96.5	92.1		0.0	0.0	0.0	0.0	0.0	0.0	
			2	124.6	37.4	31.8		0.0	0.0	0.0	0.0	0.0	0.0	
		NS	1	46.7	124.6	82.6		0.0	6.4	3.2	0.0	0.0	0.0	
			2	133.9	28.0	47.6		0.0	0.0	0.0	0.0	0.0	0.0	
			X̄	105.1	71.6	63.5	80.1	0.0	1.6	0.8	0.0	0.0	0.0	0.4
	Cyanophyta	NB	1	1,012.1	682.0	1,108.2		0.0	79.4	0.0	0.0	0.0	0.0	
			2	1,242.5	2,628.2	1,701.8		0.0	0.0	0.0	0.0	0.0	0.0	
		NS	1	1,332.4	1,451.1	276.2		15.6	130.2	0.0	0.0	9.5	0.0	
			2	666.4	1,815.5	1,295.4		0.0	0.0	0.0	127.0	0.0	0.0	
			X̄	1,063.4	1,644.2	1,095.4	1,267.7	3.9	52.4	0.0	31.8	2.4	0.0	15.1
	Euglenophyta	NB	1	56.1	24.9	47.6		0.0	0.0	0.0	0.0	6.4	0.0	
			2	74.7	21.8	9.5		0.0	0.0	0.0	0.0	6.4	0.0	
		NS	1	37.4	15.6	15.9		0.0	9.5	3.2	0.0	3.2	0.0	
			2	124.6	9.3	12.7		0.0	3.4	0.0	0.0	3.2	0.0	
			X̄	73.2	17.9	21.4	37.5	0.0	3.2	0.8	0.0	4.8	0.0	1.5
	Pyrrophyta	NB	1	0.0	34.3	15.9		0.0	0.0	0.0	0.0	0.0	0.0	
			2	34.3	49.8	6.4		0.0	0.0	0.0	0.0	0.0	0.0	
		NS	1	0.0	24.9	12.7		0.0	0.0	0.0	0.0	0.0	0.0	
			2	9.3	21.8	3.2		0.0	0.0	0.0	0.0	3.2	0.0	
			X̄	10.9	32.7	9.6	17.7	0.0	0.0	0.0	0.0	0.8	0.0	0.1

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980				1981						
				July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
3. Duck River Lillards Mill	Chlorophyta	NB	1	4,253.7	115.2	-		0.0	NS†	280.3	1,593.9	158.8	850.9	
			2	1,859.1	46.7	-		19.1		345.7	1,482.7	206.4	660.4	
		NS	1	2,438.3	46.7	-		28.6		270.9	2,016.1	101.6	654.1	
			2	6,072.3	43.6	-		25.4		255.4	1,476.4	219.1	619.1	
			X̄	3,655.9	63.1	-	1,859.5	18.3		288.1	1,642.3	171.5	693.9	562.8
	Chrysophyta	NB	1	81.0	46.7	-		50.8	NS	211.8	123.8	28.6	73.0	
			2	77.9	24.9	-		57.2		239.8	114.3	57.2	47.6	
		NS	1	74.7	37.4	-		88.9		221.1	111.1	50.8	47.6	
			2	112.1	68.5	-		88.9		190.0	123.8	15.9	50.8	
			X̄	86.4	44.4	-	65.4	71.5		215.7	118.3	38.1	54.8	99.7
	Cryptophyta	NB	1	460.9	0.0	-		0.0	NS	43.6	60.3	0.0	3.2	
			2	218.0	9.3	-		0.0		37.4	57.2	0.0	0.0	
		NS	1	404.8	0.0	-		0.0		18.7	69.9	0.0	0.0	
			2	548.1	0.0	-		0.0		3.1	50.8	0.0	0.0	
			X̄	408.0	2.3	-	205.1	0.0		25.7	59.6	0.0	0.8	17.2
	Cyanophyta	NB	1	716.2	68.5	-		0.0	NS	177.5	1,000.1	200.0	263.5	
			2	588.6	62.3	-		0.0		115.2	1,114.4	269.9	209.6	
		NS	1	607.2	0.0	-		0.0		158.8	1,101.7	130.2	238.1	
			2	1,800.0	49.8	-		6.4		149.5	828.7	177.8	209.6	
			X̄	928.0	45.2	-	486.6	1.6		150.3	1,011.2	194.5	230.2	317.6
	Euglenophyta	NB	1	12.5	6.2	-		3.2	NS	49.8	374.7	9.5	25.4	
			2	15.6	9.3	-		3.2		52.9	495.3	12.7	12.7	
		NS	1	21.8	3.1	-		9.5		21.8	428.6	6.4	38.1	
			2	56.1	0.0	-		0.0		40.5	295.3	22.2	9.5	
			X̄	26.5	4.7	-	15.6	4.0		41.3	398.5	12.7	21.4	95.6
	Pyrrophyta	NB	1	0.0	12.5	-		0.0	NS	9.3	28.6	0.0	15.9	
			2	0.0	0.0	-		0.0		12.5	28.6	0.0	9.5	
		NS	1	0.0	0.0	-		0.0		3.1	19.1	0.0	12.7	
			2	0.0	0.0	-		0.0		12.5	22.2	0.0	3.2	
			X̄	0.0	3.1	-	1.6	0.0		9.4	24.6	0.0	10.3	8.9

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980				1981						
				July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
4. Duck River Sowell Ford	Chlorophyta	NB	1	538.7	40.7	19.1		0.0	NS	470.2	-	12.7	165.1	
			2	1,093.0	96.5	31.8		6.4		277.2	-	25.4	139.7	
		NS	1	146.4	127.7	9.5		15.9		367.5	-	9.5	165.1	
			2	358.1	168.1	12.7		3.2		392.4	-	6.4	136.5	
			X̄	534.1	108.3	18.3	220.2	6.4		376.8	-	13.5	151.6	137.1
	Chrysophyta	NB	1	43.6	62.3	34.9		79.4	NS	96.5	-	38.1	34.9	
			2	24.9	28.0	15.9		63.5		102.8	-	47.6	28.8	
		NS	1	28.0	52.9	12.7		136.5		87.2	-	38.1	57.2	
			2	18.7	34.3	22.2		174.6		96.5	-	31.8	73.1	
			X̄	28.8	44.4	21.4	31.5	113.5		95.8	-	38.9	48.5	74.2
	Cryptophyta	NB	1	3.1	6.3	0.0		0.0	NS	12.5	-	0.0	0.0	
			2	3.1	6.3	0.0		0.0		9.3	-	0.0	0.0	
		NS	1	0.0	0.0	3.2		0.0		21.8	-	0.0	0.0	
			2	0.0	0.0	0.0		0.0		31.1	-	0.0	0.0	
			X̄	1.6	3.2	0.8	1.8	0.0		18.7	-	0.0	0.0	4.7
	Cyanophyta	NB	1	124.6	115.2	3.2		0.0	NS	28.0	-	63.5	117.5	
			2	3.1	15.6	108.0		0.0		130.8	-	101.6	111.1	
		NS	1	124.6	6.2	6.4		254.0		81.0	-	38.1	0.0	
			2	99.7	6.2	0.0		0.0		81.0	-	28.6	0.0	
			X̄	88.0	35.8	29.4	51.1	63.5		80.2	-	58.0	57.2	64.7
	Euglenophyta	NB	1	0.0	0.0	0.0		0.0	NS	15.6	-	0.0	0.0	
			2	0.0	0.0	0.0		0.0		3.1	-	0.0	0.0	
		NS	1	0.0	6.2	0.0		0.0		6.2	-	0.0	0.0	
			2	0.0	6.2	0.0		0.0		3.1	-	0.0	0.0	
			X̄	0.0	3.1	0.0	1.0	0.0		7.0	-	0.0	0.0	1.8
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	-	3.2	0.0	
			2	0.0	0.0	0.0		0.0		0.0	-	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	-	0.0	0.0	
			2	0.0	3.2	0.0		0.0		0.0	-	0.0	0.0	
			X̄	0.0	0.8	0.0	0.3	0.0		0.0	-	0.8	0.0	0.2

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980 July	1980 Aug	1980 Sept	1980 X̄	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 X̄
5. Duck River Halls Mill	Chlorophyta	NB	1	68.5	18.7	12.7		9.3	NS	24.9	127.0	19.1	19.1	
			2	31.1	31.1	3.2		15.6		46.7	101.6	12.7	25.4	
		NS	1	21.8	18.7	22.2		59.2		37.4	120.7	12.7	12.7	
			2	112.1	3.1	28.6		28.2		3.1	117.5	9.5	6.4	
			X̄	58.4	17.9	16.7	31.0	28.1		28.0	116.7	13.5	15.9	40.4
	Chrysophyta	NB	1	12.5	34.3	0.0		130.8	NS	62.3	31.8	63.5	47.6	
			2	24.9	28.0	3.2		118.3		65.4	19.1	54.0	50.8	
		NS	1	46.7	37.4	9.5		127.7		3.1	22.2	54.0	41.3	
			2	24.9	9.3	9.5		121.5		3.1	50.8	28.6	66.7	
			X̄	27.3	27.3	5.6	20.0	124.6		33.5	31.0	50.0	51.6	58.1
	Cryptophyta	NB	1	3.1	0.0	6.4		0.0	NS	0.0	0.0	0.0	0.0	
			2	3.1	0.0	6.4		6.2		3.1	0.0	0.0	0.0	
		NS	1	0.0	3.1	3.2		9.3		0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
			X̄	1.6	0.8	4.8	2.4	3.9		0.8	0.0	0.0	0.0	0.9
	Cyanophyta	NB	1	348.8	99.7	3.2		0.0	NS	9.3	50.8	6.4	6.4	
			2	99.7	0.0	28.6		0.0		102.8	3.2	15.9	12.7	
		NS	1	24.9	37.4	82.6		0.0		56.1	0.0	6.4	9.5	
			2	274.0	588.6	365.1		0.0		0.0	28.6	3.2	6.4	
			X̄	186.9	181.4	119.9	162.7	0.0		42.1	20.7	8.0	8.8	15.9
	Euglenophyta	NB	1	6.2	3.1	0.0		0.0	NS	9.3	0.0	0.0	9.5	
			2	0.0	0.0	0.0		0.0		0.0	6.4	0.0	15.9	
		NS	1	3.1	0.0	0.0		0.0		0.0	0.0	3.2	3.2	
			2	0.0	0.0	0.0		0.0		3.1	3.2	0.0	9.5	
			X̄	2.3	0.8	0.0	1.0	0.0		3.1	2.4	0.8	9.5	3.2
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		6.2	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	0.0	0.0	0.0		1.6	0.0	0.0	0.0	0.3

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Appendix D. (Continued)

	Phytoplankton				1980					1981				
Reach	Groups	Depths*	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
6. Duck River Dement Bridge	Chlorophyta	NB	1	12.5	34.1	57.2		59.2	NS	68.5	161.9	73.0	34.9	
			2	124.6	28.0	114.3		59.2		6.2	31.8	57.2	31.8	
		NS	1	62.3	112.1	57.2		56.1		56.1	130.2	63.5	108.0	
			2	46.7	46.7	0.0		56.1		24.9	200.3	127.0	85.7	
			X̄	61.5	55.2	57.2	58.0	57.7		38.9	131.1	80.2	65.1	74.6
	Chrysophyta	NB	1	124.6	46.7	19.1		495.1	NS	327.0	25.4	98.4	31.8	
			2	186.8	49.8	69.9		856.2		258.5	152.4	69.9	34.9	
		NS	1	398.6	37.4	60.3		881.3		339.4	127.0	25.4	28.6	
			2	118.3	15.6	6.4		734.9		255.4	127.0	41.3	31.8	
			X̄	207.1	37.4	38.9	94.5	741.9		295.1	108.0	58.8	31.8	247.1
	Cryptophyta	NB	1	0.0	0.0	0.0		9.3	NS	3.1	0.0	0.0	0.0	
			2	0.0	0.0	31.8		18.7		3.1	0.0	0.0	0.0	
		NS	1	3.1	0.0	3.2		18.7		3.1	0.0	0.0	0.0	
			2	6.2	0.0	6.4		6.3		3.1	0.0	0.0	0.0	
			X̄	2.3	0.0	10.4	4.2	13.3		3.1	0.0	0.0	0.0	3.3
	Cyanophyta	NB	1	2,621.0	2,703.0	6,648.4		252.2	NS	962.2	717.5	2,368.6	2,387.6	
			2	4,126.1	3,771.1	10,268.0		68.5		1,170.9	1,206.5	2,457.5	1,701.8	
		NS	1	5,882.4	2,447.6	9,442.5		6.2		1,077.4	2,790.8	2,676.5	3,521.1	
			2	2,631.3	1,535.2	5,442.0		373.7		1,444.9	2,394.0	2,270.1	2,686.1	
			X̄	3,815.2	2,614.2	7,954.8	4,794.7	175.2		1,163.9	1,777.2	2,443.2	2,574.2	1,626.7
	Euglenophyta	NB	1	3.1	6.2	0.0		0.0	NS	3.1	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	12.7	0.0	
		NS	1	9.3	6.2	0.0		0.0		6.2	9.5	0.0	3.2	
			2	15.6	6.2	0.0		0.0		3.1	9.5	0.0	0.0	
			X̄	7.0	4.7	0.0	3.9	0.0		3.1	4.8	3.2	0.8	2.4
	Pyrrophyta	NB	1	0.0	3.1	6.4		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	3.1	6.4		0.0		0.0	3.2	0.0	0.0	
		NS	1	0.0	3.1	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	2.3	3.2	1.8	0.0		0.0	0.8	0.0	0.0	0.2

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980 July	Aug	Sept	$\bar{X}$	1981 April	May	June	July	Aug	Sept	$\bar{X}$
7. Elk River Chennault Ford (1980) Mile 91.4 (1981)	Chlorophyta	NB	1	24.9	15.6	-		50.8	NB	52.9	12.7	-	0.0	
			2	62.3	9.3	-		28.6		112.1	0.0	-	0.0	
		NS	1	28.0	24.9	-		121.5		40.5	0.0	-	6.4	
			2	62.3	12.5	-		171.4		31.1	12.7	-	12.7	
			$\bar{X}$	44.4	15.6	-	30.0	93.1		59.2	6.4	-	4.8	40.8
	Chrysophyta	NB	1	208.6	62.3	-		136.5	NS	121.5	85.7	-	28.6	
			2	230.4	158.8	-		133.4		105.9	98.4	-	38.1	
		NS	1	261.6	105.9	-		283.4		77.9	114.3	-	15.9	
			2	239.8	190.0	-		233.6		103.8	57.2	-	28.6	
			$\bar{X}$	235.1	129.3	-	182.2	196.7		102.3	88.9	-	27.8	103.9
	Cryptophyta	NB	1	12.5	0.0	-		0.0	NS	3.1	0.0	-	0.0	
			2	0.0	0.0	-		0.0		12.5	0.0	-	0.0	
		NS	1	0.0	3.1	-		0.0		3.1	0.0	-	0.0	
			2	6.2	3.1	-		0.0		6.2	0.0	-	0.0	
			$\bar{X}$	4.7	1.6	-	3.1	0.0		6.2	0.0	-	0.0	1.6
	Cyanophyta	NB	1	0.0	24.9	-		6.4	NS	3.1	9.5	-	0.0	
			2	49.8	0.0	-		6.4		18.7	25.4	-	0.0	
		NS	1	0.0	59.2	-		0.0		3.1	0.0	-	0.0	
			2	0.0	0.0	-		6.3		21.8	0.0	-	0.0	
			$\bar{X}$	12.5	21.0	-	16.7	4.8		11.7	8.7	-	0.0	6.3
	Euglenophyta	NB	1	3.1	3.1	-		0.0	NS	3.1	0.0	-	0.0	
			2	0.0	3.1	-		0.0		6.2	0.0	-	0.0	
		NS	1	0.0	3.1	-		6.3		6.2	0.0	-	0.0	
			2	3.1	0.0	-		24.9		18.7	0.0	-	0.0	
			$\bar{X}$	1.6	2.3	-	1.9	7.8		8.6	0.0	-	0.0	4.1

Appendix D. (Continued)

				1980				1981						
Reach	Phytoplankton Groups	Depths*	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
8. Clinch River Fort Blackmore	Chlorophyta	NB	1	581.2	101.6	19.0		19.1	NS	1,289.1	19.1	0.0	0.0	
			2	973.0	171.5	9.5		12.7		1,219.2	31.8	0.0	0.0	
		NS	1	514.4	50.8	9.5		24.9		1,654.2	22.2	12.7	50.8	
			2	495.3	82.6	47.6		12.5		1,320.8	38.1	15.9	0.0	
			X̄	641.0	101.6	21.4	254.7	17.3		1,370.8	27.8	7.2	12.7	287.2
	Chrysophyta	NB	1	1,031.7	139.7	250.8		574.7		273.1	82.6	79.4	47.6	
			2	1,051.3	177.8	320.7		622.3		219.1	69.9	60.3	57.2	
		NS	1	743.0	127.0	311.2		591.7		304.8	98.4	63.5	76.2	
			2	736.6	171.5	336.6		423.5		184.2	98.4	60.3	57.2	
			X̄	886.2	154.0	304.8	448.3	553.1		245.3	87.3	65.9	59.6	202.2
	Cryptophyta	NB	1	0.0	0.0	3.2		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	3.2	1.1	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	52.2	0.0	0.0		0.0		9.5	38.1	3.2	6.4	
			2	98.2	0.0	3.2		0.0		0.0	0.0	0.0	9.5	
		NS	1	0.0	0.0	0.0		149.5		196.9	0.0	3.2	0.0	
			2	12.7	254.0	50.8		0.0		25.4	3.2	0.0	0.0	
			X̄	40.8	63.5	13.5	39.3	37.3		58.0	10.3	1.6	4.0	22.2
	Euglenophyta	NB	1	91.4	0.0	12.7		0.0	NS	34.9	3.2	0.0	3.2	
			2	104.5	0.0	6.4		0.0		12.7	6.4	0.0	15.9	
		NS	1	50.8	0.0	9.5		0.0		0.0	0.0	0.0	9.5	
			2	50.8	0.0	0.0		3.2		0.0	3.2	0.0	9.5	
			X̄	74.4	0.0	7.2	27.2	0.8		11.9	3.2	0.0	9.5	5.1
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	3.2		3.2		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	0.8	0.2	0.0		0.0	0.0	0.0	0.0	0.0

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Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980				1981						
				July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
9. Clinch River Kyles Ford	Chlorophyta	NB	1	215.9	171.5	81.0		38.1	NS	911.2	6.4	3.2	25.4	
			2	209.6	254.0	102.8		22.0		682.6	3.2	0.0	12.7	
		NS	1	222.3	203.2	112.1		0.0		739.8	6.4	12.7	0.0	
			2	177.8	235.0	143.2		15.9		1,082.7	31.8	0.0	0.0	
			X̄	206.4	215.9	109.8	177.4	19.0		854.1	12.0	4.0	9.5	179.7
	Chrysophyta	NB	1	133.4	101.6	99.7		511.1	NS	187.3	38.1	44.5	57.2	
			2	165.1	82.6	124.6		730.3		193.7	34.9	47.6	66.7	
		NS	1	222.3	101.6	109.0		435.0		209.6	28.6	44.5	73.0	
			2	196.9	63.5	109.0		571.5		260.4	25.4	38.1	60.3	
			X̄	179.4	87.3	110.6	125.8	562.0		212.8	31.8	43.7	64.3	182.9
	Cryptophyta	NB	1	0.0	0.0	28.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	6.2		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	19.1	18.7		0.0		0.0	0.0	0.0	0.0	
			2	0.0	38.1	43.6		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	14.3	24.1	12.8	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	12.7	101.6	99.7		0.0	NS	0.0	44.5	0.0	19.1	
			2	0.0	152.4	49.9		0.0		0.0	6.4	0.0	9.5	
		NS	1	6.4	304.9	49.9		0.0		104.8	0.0	0.0	6.4	
			2	6.4	152.4	99.7		0.0		50.8	6.4	0.0	0.0	
			X̄	6.4	177.8	74.8	86.3	0.0		38.9	14.3	0.0	8.8	12.4
	Euglenophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	3.2	
			2	12.7	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	6.4	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	3.2	
			X̄	3.2	0.0	0.0	1.1	0.0		0.0	0.0	0.0	3.2	0.6

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980 July	1980 Aug	1980 Sept	1980 X̄	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 X̄
10. Copper Creek Mile 7.7 Mile 1.9	Chlorophyta	NB	1	44.5	0.0	22.2		49.8	NS	0.0	15.9	0.0	0.0	
			2	50.8	0.0	31.8		49.8		0.0	15.9	0.0	0.0	
		NS	1	32.7	50.8	44.5		21.8		0.0	0.0	12.7	3.2	
			2	25.4	0.0	22.2		21.8		0.0	0.0	0.0	0.0	
			X̄	38.4	12.7	30.2	27.1	35.8		0.0	8.0	3.2	0.8	9.5
	Chrysophyta	NB	1	190.5	63.5	266.7		498.2	NS	174.6	47.6	44.5	47.6	
			2	215.9	69.9	165.1		772.3		184.2	31.8	47.6	69.9	
		NS	1	404.9	171.5	200.0		688.2		149.2	50.8	41.3	54.0	
			2	209.6	196.9	244.5		563.6		139.7	44.5	54.0	54.0	
			X̄	255.2	125.5	219.1	199.9	630.6		161.9	43.7	46.9	56.4	187.9
	Cryptophyta	NB	1	0.0	0.0	9.5		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	9.5		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	12.7		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	8.7	2.9	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	12.7	254.0	187.3		0.0	NS	0.0	0.0	0.0	57.2	
			2	0.0	152.4	244.5		0.0		0.0	0.0	0.0	76.2	
		NS	1	0.0	108.0	212.7		3.1		0.0	0.0	0.0	0.0	
			2	0.0	0.0	222.3		0.0		0.0	0.0	0.0	0.0	
			X̄	3.2	128.6	216.7	116.2	0.8		0.0	0.0	0.0	33.4	6.8
	Euglenophyta	NB	1	0.0	6.4	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	6.4	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	6.4	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	6.4	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	1.6	4.8	0.0	2.1	0.0		0.0	0.0	0.0	0.0	0.0
	Pyrrophyta	NB	1	0.0	0.0	3.2		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	0.8	0.3	0.0		0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

				1980				1981						
Reach	Phytoplankton Groups	Depths*	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
11. Nolichucky River Hale Bridge	Chlorophyta	NB	1	109.0	3,587.8	466.7		15.6	NB	127.0	152.4	139.7	127.0	
			2	199.3	4,311.7	561.0		24.9		193.7	225.4	108.0	101.6	
		NS	1	214.9	3,937.0	793.8		9.4		104.8	238.1	193.7	101.6	
			2	124.6	5,111.8	619.1		15.6		152.4	149.2	136.5	123.8	
			X̄	162.0	4,237.1	610.2	1,669.7	16.4		144.5	191.3	144.5	113.5	122.0
	Chrysophyta	NB	1	31.1	368.3	241.3		277.2	NS	463.6	50.8	28.6	34.9	
			2	43.6	400.1	228.6		339.4		514.4	41.3	50.8	28.6	
		NS	1	40.5	330.2	219.1		320.7		238.1	108.0	73.0	25.4	
			2	118.3	304.8	209.6		277.2		365.1	79.4	69.9	22.2	
			X̄	58.4	350.9	224.7	211.3	303.6		395.3	69.9	55.6	27.8	170.4
	Cryptophyta	NB	1	0.0	108.0	31.8		9.3	NS	0.0	0.0	0.0	0.0	
			2	0.0	38.1	22.2		12.5		0.0	0.0	0.0	0.0	
		NS	1	0.0	95.3	34.9		9.3		0.0	0.0	0.0	0.0	
			2	0.0	120.7	22.2		3.1		0.0	0.0	0.0	0.0	
			X̄	0.0	90.5	27.8	39.4	8.6		0.0	0.0	0.0	0.0	1.7
	Cyanophyta	NB	1	0.0	311.2	412.8		0.0	NS	25.4	12.7	12.7	54.0	
			2	49.8	1,346.2	133.4		3.1		15.9	9.5	15.9	6.4	
		NS	1	149.5	1,289.1	320.7		0.0		6.4	0.0	28.6	6.4	
			2	0.0	1,517.7	238.1		0.0		31.8	19.1	34.9	0.0	
			X̄	49.8	1,116.1	276.3	480.7	0.8		19.9	10.3	23.0	16.7	14.1
	Euglenophyta	NB	1	0.0	31.8	6.4		0.0	NS	0.0	0.0	3.2	3.2	
			2	0.0	44.5	6.4		0.0		0.0	3.2	0.0	3.2	
		NS	1	0.0	31.8	3.2		0.0		0.0	6.4	0.0	0.0	
			2	0.0	57.2	0.0		0.0		0.0	6.4	0.0	0.0	
			X̄	0.0	41.3	4.0	15.1	0.0		0.0	4.0	0.8	1.6	1.3
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	9.5		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	3.2	1.3	0.0		0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate		1980					1981				
				July	Aug	Sept	$\bar{X}$	April	May	June	July	Aug	Sept	$\bar{X}$
12. Holston River (N.F.) Click Island	Chlorophyta	NB	1	57.2	0.0	69.9		15.9	NS	6.4	3.2	0.0	19.1	
			2	57.2	0.0	54.0		15.9		0.0	12.7	0.0	19.1	
		NS	1	38.1	0.0	22.2		37.4		0.0	0.0	0.0	3.2	
			2	0.0	6.4	69.9		44.5		0.0	0.0	0.0	9.5	
			$\bar{X}$	38.1	1.6	54.0	31.2	28.4		1.6	4.0	0.0	12.7	9.3
	Chrysophyta	NB	1	215.9	120.7	206.4		866.6	NS	120.7	73.0	44.5	44.5	
			2	285.8	82.6	111.1		609.6		54.0	98.4	38.1	50.8	
		NS	1	298.5	292.1	171.4		302.1		76.2	111.1	34.9	85.7	
			2	330.2	209.6	139.7		666.8		98.4	120.7	47.6	28.6	
			$\bar{X}$	282.6	176.3	157.2	205.3	611.3		87.3	100.8	41.3	52.4	178.6
	Cryptophyta	NB	1	0.0	0.0	15.9		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	6.4		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	25.4		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	12.7		0.0		0.0	0.0	0.0	0.0	
			$\bar{X}$	0.0	0.0	15.1	1.3	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	0.0	44.5	139.7		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	235.0	120.7		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	311.2	101.6		0.0		0.0	0.0	0.0	203.2	
			2	0.0	304.9	457.2		0.0		0.0	0.0	0.0	0.0	
			$\bar{X}$	0.0	223.9	204.8	142.9	0.0		0.0	0.0	0.0	50.8	10.2
	Euglenophyta	NB	1	19.1	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	25.4	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	19.1	0.0	0.0		12.5		0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.2		0.0		0.0	0.0	0.0	0.0	
			$\bar{X}$	15.9	0.0	0.8	5.6	3.1		0.0	0.0	0.0	0.0	0.6
	Pyrrophyta	NB	1	0.0	0.0	3.2		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			$\bar{X}$	0.0	0.0	0.8	0.3	0.0		0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980 July	1980 Aug	1980 Sept	X̄	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	X̄
13. Holston River Saltville	Chlorophyta	NB	1	59.2	927.1	46.7		3.1	NS	0.0	101.6	0.0	12.7	
			2	74.7	749.3	137.0		3.1		15.9	142.9	12.7	25.4	
		NS	1	0.0	977.9	102.8		0.0		0.0	38.1	12.7	12.7	
			2	43.6	895.4	96.5		3.1		6.4	50.8	0.0	25.4	
			X̄	44.4	887.4	95.8	342.5	2.3		5.6	83.4	6.4	19.1	23.3
	Chrysophyta	NB	1	49.8	425.5	31.1		323.9	NS	60.3	41.3	34.9	22.2	
			2	49.8	273.1	40.5		280.3		63.5	41.3	57.2	22.2	
		NS	1	46.7	279.4	84.1		224.2		60.3	44.5	25.4	22.2	
			2	46.7	177.8	49.8		277.2		60.3	28.6	31.8	41.3	
			X̄	48.3	289.0	51.4	129.5	276.4		61.1	38.9	37.3	27.0	88.1
	Cryptophyta	NB	1	0.0	50.8	31.4		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	25.4	31.4		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	37.4		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	12.5		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	19.1	28.2	15.7	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	124.6	0.0	0.0		0.0	NS	0.0	0.0	0.0	9.5	
			2	0.0	12.7	0.0		0.0		0.0	0.0	25.4	19.1	
		NS	1	0.0	6.4	0.0		21.8		0.0	0.0	0.0	6.4	
			2	0.0	6.4	149.5		0.0		0.0	0.0	0.0	3.2	
			X̄	31.2	6.4	37.4	25.0	5.5		0.0	0.0	6.4	9.6	4.3
	Euglenophyta	NB	1	0.0	0.0	3.1		0.0	NS	3.2	0.0	0.0	6.4	
			2	0.0	6.4	0.0		0.0		0.0	0.0	0.0	3.2	
		NS	1	0.0	6.4	6.2		0.0		3.2	3.2	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	3.2	2.3	1.8	0.0		1.6	0.8	0.0	2.4	1.0
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	3.1		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	0.8	0.3	0.0		0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

					1980					1981				
Reach	Phytoplankton Groups	Depths*	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
14. Powell River Buchanan Ford	Chlorophyta	NB	1	120.7	247.7	193.1		3.1	NS	34.9	6.4	0.0	57.2	
			2	38.1	254.0	249.1		3.1		50.8	0.0	-	47.6	
		NS	1	108.0	317.5	286.5		12.5		66.7	0.0	0.0	28.6	
			2	38.1	533.4	239.8		12.5		120.7	3.2	0.0	31.8	
			X̄	74.7	338.2	242.1	218.3	7.8		68.3	2.4	0.0	41.3	25.2
	Chrysophyta	NB	1	273.1	196.9	65.4		473.3	NS	95.3	34.9	57.2	63.5	
			2	298.5	146.1	49.8		492.0		108.0	28.6	-	69.9	
		NS	1	222.3	177.8	77.9		417.3		88.9	47.6	50.8	54.0	
			2	228.6	139.7	84.1		395.5		82.6	28.6	73.0	50.8	
			X̄	255.6	165.1	69.3	163.4	444.5		93.7	34.9	60.3	59.6	142.7
	Cryptophyta	NB	1	0.0	0.0	12.5		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.1		0.0		0.0	0.0	-	0.0	
		NS	1	6.4	0.0	3.1		0.0		0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	1.6	0.0	4.7	2.1	0.0		0.0	0.0	0.0	0.0	0.0
	Cyanophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	6.4	0.0	0.0		0.0		0.0	0.0	-	6.4	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			2	0.0	101.6	3.1		0.0		0.0	0.0	0.0	3.2	
			X̄	1.6	25.4	0.8	9.3	0.0		0.0	0.0	0.0	2.4	0.5
	Euglenophyta	NB	1	25.4	0.0	3.1		3.1	NS	0.0	0.0	0.0	0.0	
			2	0.0	6.4	3.1		0.0		0.0	0.0	-	0.0	
		NS	1	19.1	19.1	6.2		0.0		0.0	0.0	0.0	0.0	
			2	12.7	0.0	9.3		0.0		0.0	0.0	0.0	0.0	
			X̄	14.3	6.4	5.4	8.7	0.8		0.0	0.0	0.0	0.0	0.2
	Pyrrophyta	NB	1	0.0	0.0	3.1		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	3.1		0.0		0.0	0.0	-	0.0	
		NS	1	0.0	0.0	6.2		0.0		0.0	0.0	0.0	0.0	
			2	6.4	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	1.6	0.0	3.1	1.6	0.0		0.0	0.0	0.0	0.0	0.0

Appendix D. (Continued)

Reach	Phytoplankton Groups	Depths*	Replicate	1980				1981						
				July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
15. Powell River Fletcher Ford	Chlorophyta	NB	1	82.6	323.9	691.3		40.5	NS	12.7	0.0	0.0	31.8	
			2	38.1	190.5	666.4		15.6		6.4	0.0	0.0	41.3	
		NS	1	101.6	184.2	423.5		18.7		98.4	0.0	0.0	22.2	
			2	50.8	190.5	560.5		18.7		38.1	0.0	0.0	28.6	
			X̄	68.3	222.3	585.4	292.0	23.4		38.9	0.0	0.0	31.0	18.7
	Chrysophyta	NB	1	247.7	120.7	121.5		448.5	NS	184.2	54.0	38.1	54.0	
			2	209.6	114.3	81.0		383.0		184.2	25.4	34.9	38.1	
		NS	1	171.5	101.6	81.0		407.9		177.8	31.8	47.6	66.7	
			2	247.7	63.5	56.1		560.5		228.6	34.9	41.3	47.6	
			X̄	219.1	100.0	84.9	134.7	450.0		193.7	36.5	40.5	51.6	154.5
	Cryptophyta	NB	1	0.0	0.0	43.6		6.2	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	18.7		3.1		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	18.7		3.1		0.0	0.0	0.0	0.0	
			2	0.0	0.0	18.7		0.0		0.0	0.0	0.0	0.0	
			X̄	0.0	0.0	24.9	8.3	3.1		0.0	0.0	0.0	0.0	0.6
	Cyanophyta	NB	1	12.7	0.0	0.0		0.0	NS	0.0	0.0	0.0	6.4	
			2	6.4	0.0	74.7		0.0		3.2	0.0	0.0	0.0	
		NS	1	12.7	101.6	0.0		3.1		3.2	0.0	0.0	6.4	
			2	19.1	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	12.7	25.4	18.7	18.9	0.8		1.6	0.0	0.0	3.2	1.1
	Euglenophyta	NB	1	57.2	12.7	6.2		0.0	NS	0.0	0.0	0.0	0.0	
			2	50.8	6.4	15.6		0.0		0.0	0.0	0.0	0.0	
		NS	1	25.4	12.7	12.5		0.0		0.0	0.0	0.0	0.0	
			2	101.6	12.7	15.6		0.0		0.0	0.0	0.0	6.4	
			X̄	58.8	11.1	12.5	27.5	0.0		0.0	0.0	0.0	1.6	0.3
	Pyrrophyta	NB	1	0.0	0.0	0.0		0.0	NS	0.0	0.0	0.0	0.0	
			2	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
		NS	1	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			2	6.4	0.0	0.0		0.0		0.0	0.0	0.0	0.0	
			X̄	1.6	0.0	0.0	0.5	0.0		0.0	0.0	0.0	0.0	0.0

*NB = Near bottom
NS = Near surface
†Sample lost or not processed

‡No survey conducted

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Appendix E. Total Zooplankton Abundance (no/m^3), Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Reach	Replicate	1980 July	1980 Aug	1980 Sept	1980 X̄	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 X̄
1. Buffalo River												
Metal Ford (1980)	1	503	1,940	34		335	856	84	0	468	34	
Topsy Bridge (1981)	2	1,523	571	268		939	419	168	0	168	0	
	X̄	1,013	1,256	151	807	637	638	126	0	318	17	289
2. Paint Rock River												
Estill Fork (1980)	1	26,681	7,804	15,350		168	285	335	168	4,359	1,087	
Mile 60.0 (1981)	2	16,305	4,595	12,512		101	17	0	0	1,019	536	
	X̄	21,493	6,200	13,931	13,875	135	151	168	84	2,689	812	648
3. Duck River												
Lillards Mill	1	1,305	1,056	855		1,187	NS*	402	1,087	2,676	2,793	
	2	3,695	2,340	1,088		1,053		369	855	2,776	3,559	
	X̄	2,500	1,698	972	1,723	1,120		386	971	2,726	3,176	1,676
4. Duck River												
Sowell Ford	1	453	953	203		854	NS	101	420	2,043	118	
	2	303	2,240	169		619		101	84	1,355	268	
	X̄	378	1,597	186	720	737		101	252	1,699	193	596
5. Duck River												
Halls Mill	1	889	503	436		636	NS	269	-†	2,943	419	
	2	721	1,003	1,072		1,420		17	34	5,102	604	
	X̄	805	753	754	771	1,028		143	34	4,023	512	1,272
6. Duck River												
Dement Bridge	1	3,193	1,357	922		42,588	NS	419	2,173	869	537	
	2	3,512	1,857	1,089		26,823		268	2,004	84	385	
	X̄	3,353	1,607	1,006	1,988	34,706		344	2,089	477	461	7,615

Appendix E. (Continued)

Reach	Replicate	1980				1981						
		July	Aug	Sept	$\bar{X}$	April	May	June	July	Aug	Sept	$\bar{X}$
7. Elk River												
Chennault Ford (1980)	1	972	699	6,967		3,610	NS	202	168	-	185	
Mile 91.4 (1981)	2	939	752	9,136		3,460		0	17	-	151	
	$\bar{X}$	956	711	8,052	3,239	3,535		101	93	-	168	974
8. Clinch River												
Fort Blackmore	1	1,103	954	1,036		1,440	NS	335	0	17	353	
	2	535	971	4,296		1,037		84	101	185	168	
	$\bar{X}$	819	963	2,666	1,483	1,239		210	51	101	261	372
9. Clinch River												
Kyles Ford	1	854	719	870		1,087	NS	0	0	84	335	
	2	990	702	403		1,022		0	0	84	67	
	$\bar{X}$	922	711	637	756	1,055		0	0	84	201	268
10. Copper Creek												
Mile 7.7 (1980)	1	1,555	2,090	771		688	NS	252	0	252	0	
Mile 1.9 (1981)	2	1,806	336	921		1,104		84	0	84	17	
	$\bar{X}$	1,681	1,213	846	1,247	896		158	0	168	9	246
11. Nolichucky River												
Hale Bridge	1	2,940	587	1,171		518	NS	84	0	84	385	
	2	7,249	2,023	1,357		1,670		252	251	84	269	
	$\bar{X}$	5,095	1,305	1,264	2,555	1,094		168	126	84	327	360
12. Holston River (N.F.)												
Click Island	1	1,071	1,105	352		2,726	NS	84	101	201	168	
	2	1,289	504	435		1,354		0	0	17	17	
	$\bar{X}$	1,180	805	394	793	2,040		42	51	109	93	467

Appendix E. (Continued)

Reach	Replicate	1980 July	1980 Aug	1980 Sept	1980 $\bar{X}$	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 $\bar{X}$
13. Holston River (N.F.)												
Saltville	1	1,738	587	402		2,958	NS	168	335	101	503	
	2	4,359	871	319		2,089		436	252	84	454	
	$\bar{X}$	3,049	729	361	1,379	2,524		302	294	93	479	738
14. Powell River												
Buchanan Ford	1	955	686	2,240		1,038	NS	50	84	519	33	
	2	1,139	954	235		1,038		185	0	452	17	
	$\bar{X}$	1,047	820	1,238	1,035	1,038		118	42	486	25	342
15. Powell River												
Fletcher Ford	1	369	853	202		953	NS	84	17	386	468	
	2	803	754	135		202		84	0	671	418	
	$\bar{X}$	586	804	169	519	578		84	9	529	443	328

*No survey conducted
†Sample lost or not processed

Appendix F. Zooplankton Abundance (no/m^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Reach	Zooplankton Groups	Replicate	1980 July	1980 Aug	1980 Sept	1980 $\bar{X}$	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 $\bar{X}$
1. Buffalo River	Cladocera	1	0	17	17		0	101	0	0	133	0	
Metal Ford (1980)		2	251	17	67		17	0	0	0	84	0	
Topsy Bridge (1981)		$\bar{X}$	126	17	42	62	9	51	0	0	109	0	28
	Copepoda	1	251	251	17		84	252	84	0	0	17	
		2	84	101	33		168	335	84	0	0	0	
		$\bar{X}$	168	176	25	123	126	294	84	0	0	9	85
	Rotifera	1	252	1,672	0		251	503	0	0	335	17	
		2	1,188	453	168		754	84	84	0	84	0	
		$\bar{X}$	720	1,063	84	622	503	294	42	0	210	9	176
2. Paint Rock River	Cladocera	1	3,966	200	101		0	33	0	0	518	351	
Estill Fork (1980)		2	2,314	435	953		17	0	0	0	184	118	
Mile 60.0 (1981)		$\bar{X}$	3,140	318	527	1,328	9	17	0	0	351	235	102
	Copepoda	1	6,638	4,344	3,123		0	84	84	84	2,171	736	
		2	5,010	1,871	4,460		0	17	0	0	167	418	
		$\bar{X}$	5,824	3,108	3,792	4,241	0	51	42	42	1,169	577	313
	Rotifera	1	16,077	3,260	12,126		168	168	251	84	1,670	0	
		2	8,981	2,289	7,099		84	0	0	0	668	0	
		$\bar{X}$	12,529	2,775	9,613	8,305	126	84	126	42	1,169	0	258
3. Duck River	Cladocera	1	0	536	502		435	NS*	84	84	168	101	
Lillards Mill		2	17	1,504	335		133		101	101	269	168	
		$\bar{X}$	9	1,020	419	482	284		93	93	219	135	164
	Copepoda	1	67	335	168		418	NS	318	251	335	1,505	
		2	167	668	501		502		268	502	418	1,253	
		$\bar{X}$	117	502	335	318	460		293	377	377	1,379	577
	Rotifera	1	1,238	185	185		334	NS	0	752	2,173	1,187	
		2	3,511	168	252		418		0	252	2,089	2,138	
		$\bar{X}$	2,375	177	219	923	376		0	502	2,131	1,663	934

Appendix F. (Continued)

			1980				1981						
Reach	Zooplankton Groups	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
4. Duck River Sowell Ford	Cladocera	1	0	251	118		101	NS	84	0	17	0	
		2	84	101	118		117		0	0	101	17	
		X̄	42	176	118	112	109		42	0	59	9	44
	Copepoda	1	0	167	51		418	NS	17	168	419	34	
		2	17	384	51		251		17	84	251	251	
		X̄	9	276	51	112	335		17	126	335	143	191
	Rotifera	1	453	535	34		335	NS	0	252	1,607	84	
		2	202	1,755	0		251		84	0	1,003	0	
		X̄	328	1,145	17	497	293		42	126	1,305	42	362
5. Duck River Halls Mill	Cladocera	1	17	0	34		251	NS	84	-†	351	0	
		2	84	84	134		668		0	0	786	0	
		X̄	51	42	84	59	460		42	0	569	0	238
	Copepoda	1	268	252	184		301	NS	101	-	1,420	84	
		2	50	167	352		501		17	0	2,724	269	
		X̄	159	210	268	212	401		59	0	2,072	177	602
	Rotifera	1	604	251	218		84	NS	84	-	1,172	335	
		2	587	752	586		251		0	34	1,592	335	
		X̄	596	502	402	500	168		42	34	1,382	335	432
6. Duck River Dement Bridge	Cladocera	1	17	17	0		8,936	NS	84	0	17	0	
		2	84	84	84		8,601		0	0	0	33	
		X̄	51	51	42	48	8,769		42	0	9	17	1,767
	Copepoda	1	251	335	184		21,293	NS	84	168	17	185	
		2	1,003	585	101		15,966		17	0	0	184	
		X̄	627	460	143	410	18,630		51	84	9	185	3,791
	Rotifera	1	2,925	1,005	738		12,359	NS	251	2,005	835	352	
		2	2,425	1,188	904		2,256		251	2,004	84	168	
		X̄	2,675	1,097	821	1,531	7,308		251	2,005	460	260	2,057

Appendix F. (Continued)

Reach	Zooplankton Groups	Replicate	1980				1981						
			July	Aug	Sept	$\bar{X}$	April	May	June	July	Aug	Sept	$\bar{X}$
7. Elk River	Cladocera	1	0	0	34		352	NS	84	84	-	0	
Chennault Ford (1980)		2	17	0	0		870		0	0	-	0	
Mile 91.4 (1981)		$\bar{X}$	9	0	17	9	611		42	42	-	0	174
	Copepoda	1	33	84	168		669	NS	34	84	-	101	
		2	251	251	33		418		0	17	-	67	
		$\bar{X}$	142	168	101	137	544		17	51	-	84	174
	Rotifera	1	939	585	6,765		2,589	NS	84	0	-	84	
		2	671	501	9,103		2,172		0	0	-	84	
		$\bar{X}$	805	680	7,934	3,140	2,381		42	0	-	84	627
8. Clinch River	Cladocera	1	752	0	33		17	NS	84	0	0	0	
Fort Blackmore		2	167	0	585		17		0	101	84	84	
		$\bar{X}$	460	0	309	256	17		42	51	42	42	39
	Copepoda	1	17	33	66		501	NS	0	0	0	168	
		2	50	84	101		518		0	0	0	84	
		$\bar{X}$	34	59	84	59	510		0	0	0	126	127
	Rotifera	1	334	921	937		922	NS	251	0	17	185	
		2	318	887	3,610		502		84	0	101	0	
		$\bar{X}$	326	904	2,274	1,168	712		168	0	59	93	206
9. Clinch River	Cladocera	1	84	0	151		84	NS	0	0	0	0	
Kyles Ford		2	0	0	352		0		0	0	0	17	
		$\bar{X}$	42	0	252	98	42		0	0	0	9	10
	Copepoda	1	184	84	200		334	NS	0	0	84	335	
		2	84	33	34		686		0	0	0	50	
		$\bar{X}$	134	59	117	103	510		0	0	42	193	149
	Rotifera	1	586	635	519		669	NS	0	0	0	0	
		2	906	669	17		336		0	0	84	0	
		$\bar{X}$	746	652	268	555	503		0	0	42	0	109

Appendix F. (Continued)

	Zooplankton			1980					1981				
Reach	Groups	Replicate	July	Aug	Sept	X̄	April	May	June	July	Aug	Sept	X̄
10. Copper Creek Mile 7.7 (1980) Mile 1.9 (1981)	Cladocera	1	0	334	168		0	NS	84	0	84	0	
		2	17	0	84		0		0	0	0	0	
		X̄	9	167	126	101	0		42	0	42	0	17
	Copepoda	1	167	585	351		352	NS	84	0	0	0	
		2	251	84	335		602		0	0	0	0	
		X̄	209	335	343	296	477		42	0	0	0	104
	Rotifera	1	1,388	1,171	252		336	NS	84	0	168	0	
		2	1,538	252	502		502		84	0	84	17	
		X̄	1,463	712	377	851	419		84	0	126	9	128
11. Nolichucky River Hale Bridge	Cladocera	1	50	84	167		0	NS	0	0	0	84	
		2	184	101	101		0		0	0	0	101	
		X̄	117	93	134	115	0		0	0	0	93	19
	Copepoda	1	51	84	251		518	NS	0	0	84	217	
		2	552	167	168		1,169		0	167	84	84	
		X̄	302	126	210	212	844		0	84	84	151	232
	Rotifera	1	2,839	419	753		0	NS	84	0	0	84	
		2	6,513	1,755	1,088		501		252	84	0	84	
		X̄	4,676	1,087	921	2,228	251		168	42	0	84	109
12. Holston River (N.F.) Click Island	Cladocera	1	17	0	167		34	NS	0	0	33	0	
		2	84	0	0		17		0	0	17	17	
		X̄	51	0	84	45	26		0	0	25	9	12
	Copepoda	1	167	84	101		1,187	NS	0	101	84	84	
		2	84	84	184		1,002		0	0	0	0	
		X̄	126	84	143	117	1,095		0	51	42	42	246
	Rotifera	1	887	1,021	84		1,505	NS	84	0	84	84	
		2	1,121	420	251		335		0	0	0	0	
		X̄	1,004	721	168	631	920		42	0	42	42	209

Appendix F. (Continued)

Reach	Zooplankton Groups	Replicate	1980 July	1980 Aug	1980 Sept	1980 $\bar{X}$	1981 April	1981 May	1981 June	1981 July	1981 Aug	1981 Sept	1981 $\bar{X}$
13. Holston River (N.F.) Saltville	Cladocera	1	201	17	33		0	NS	0	0	17	84	
		2	184	0	17		0		84	168	84	84	
		$\bar{X}$	193	9	25	75	0		42	84	51	84	52
	Copepoda	1	201	134	67		869	NS	0	251	0	251	
		2	501	101	84		836		17	0	0	118	
		$\bar{X}$	351	118	76	181	853		9	126	0	185	234
	Rotifera	1	1,336	436	302		2,089	NS	168	84	84	168	
		2	3,674	770	218		1,253		335	84	0	252	
		$\bar{X}$	2,505	603	260	1,123	1,671		252	84	42	210	452
14. Powell River Buchanan Ford	Cladocera	1	84	167	1,287		167	NS	0	0	0	0	
		2	17	0	117		17		0	0	167	0	
		$\bar{X}$	51	84	702	279	92		0	0	84	0	35
	Copepoda	1	0	418	785		369	NS	50	84	435	0	
		2	34	268	101		769		17	0	118	0	
		$\bar{X}$	17	343	443	268	569		34	42	277	0	184
	Rotifera	1	871	101	168		502	NS	0	0	84	33	
		2	1,088	686	17		252		168	0	167	17	
		$\bar{X}$	980	394	93	489	377		84	0	126	25	122
15. Powell River Fletcher Ford	Cladocera	1	17	167	0		0	NS	0	0	0	17	
		2	0	84	34		17		0	0	17	0	
		$\bar{X}$	9	126	17	50	9		0	0	9	9	5
	Copepoda	1	184	17	84		786	NS	0	0	118	33	
		2	0	84	0		101		0	0	318	84	
		$\bar{X}$	92	51	42	62	444		0	0	218	59	144
	Rotifera	1	168	669	118		167	NS	84	17	268	418	
		2	803	586	101		84		84	0	336	334	
		$\bar{X}$	486	628	110	408	126		84	9	302	376	179

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*No survey conducted

†Sample lost or not processed

Appendix G. Suspended Solids Data Collected from Surface and Near Bottom Depths at 15 Designated Study Reaches, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Study Reach	Location	Replicate	Dry Weight (mg per liter) 1980 July	August	Sept	$\bar{X}$	1981 April	May	June	July	August	Sept	$\bar{X}$
1. Buffalo River	Surface	1	15	10	14		14	2	12	8	6	9	
Metal Ford (1980)		2	15	10	12		15	28	16	10	5	7	
Topsy Bridge (1981)	Bottom	1	15	12	14		18	14	8	10	4	6	
		2	-*	11	17		13	14	12	12	4	7	
		$\bar{X}$	15	11	14	13	15	15	12	10	5	7	11
2. Paint Rock River	Surface	1	3	8	21		2	3	3	3	3	6	
Estill Fork (1980)		2	4	2	32		2	4	3	5	4	3	
Mile 60.0 (1981)	Bottom	1	2	8	19		2	3	3	9	4	3	
		2	9	32	31		2	4	3	15	6	3	
		$\bar{X}$	5	14	26	14	2	4	3	8	4	4	4
3. Duck River	Surface	1	-	15	10		17	NS.	14	9	11	8	
Lillards Mill		2	9	2	11		15		13	8	11	9	
	Bottom	1	-	29	12		16		12	9	11	7	
		2	8	15	11		16		-	8	11	7	
		$\bar{X}$	9	15	11	12	16		13	9	11	8	11
4. Duck River	Surface	1	24	52	11		10	NS	24	15	28	11	
Sowell Ford		2	27	21	17		10		23	14	27	15	
	Bottom	1	31	10	29		9		19	13	30	14	
		2	19	32	11		10		20	15	29	14	
		$\bar{X}$	25	29	17	24	10		22	14	29	14	18
5. Duck River	Surface	1	11	14	15		10	NS	20	10	49	13	
Halls Mill		2	15	7	15		8		23	9	49	10	
	Bottom	1	11	5	14		9		22	10	51	9	
		2	27	-	16		8		22	10	51	9	
		$\bar{X}$	16	9	15	14	9		22	10	50	10	20

Appendix G. (Continued)

Study Reach	Location	Replicate	Dry Weight (mg per liter)										
			1980				1981						
			July	August	Sept	$\bar{X}$	April	May	June	July	August	Sept	$\bar{X}$
6. Duck River	Surface	1	8	2	9		6	NS	12	19	19	23	
Dement Bridge		2	9	-	10		6		15	18	27	24	
	Bottom	1	9	2	9		3		16	19	23	24	
		2	6	-	9		11		17	21	23	20	
		$\bar{X}$	8	2	9	7	7		15	19	23	23	17
7. Elk River	Surface	1	6	10	7		15	NS	33	38	36	15	
Chennault Ford (1980)		2	5	13	7		13		42	38	31	-	
Mile 91.4 (1981)	Bottom	1	4	2	8		14		44	40	24	14	
		2	2	2	9		12		40	40	30	12	
		$\bar{X}$	4	7	8	6	14		40	39	30	14	28
8. Clinch River	Surface	1	36	28	32		6	NS	13	18	27	31	
Fort Blackmore		2	32	27	34		4		14	16	26	31	
	Bottom	1	31	14	32		6		11	11	30	32	
		2	42	27	32		6		13	17	33	23	
		$\bar{X}$	35	24	33	31	6		13	16	29	29	18
9. Clinch River	Surface	1	14	14	15		8	NS	10	15	29	36	
Kyles Ford		2	12	15	15		15		9	15	31	34	
	Bottom	1	14	26	16		12		10	17	28	34	
		2	15	15	13		12		7	16	29	35	
		$\bar{X}$	14	18	15	15	12		9	16	29	35	20
10. Copper Creek	Surface	1	14	10	11		5	NS	13	19	13	9	
Mile 7.7 (1980)		2	12	13	12		7		15	19	12	9	
Mile 1.9 (1981)	Bottom	1	15	9	10		6		15	20	17	9	
		2	14	12	11		6		10	22	16	8	
		$\bar{X}$	14	11	11	12	6		13	20	15	9	13

Appendix G. (Continued)

Study Reach	Location	Replicate	Dry Weight (mg per liter)										
			1980				1981						
			July	August	Sept	X̄	April	May	June	July	August	Sept	X̄
11. Nolichucky River Hale Bridge	Surface	1	37	-	15*		20	NS	16	23	16	13	
		2	34	16	15		24		28	22	17	13	
	Bottom	1	30	16	14		23		12	21	15	14	
		2	37	18	14		22		4	23	15	13	
		X̄	35	13	15	22	22		15	22	16	13	18
12. Holston River (N.F.) Click Island	Surface	1	8	9	7		10	NS	8	11	8	12	
		2	8	8	8		11		8	11	8	9	
	Bottom	1	6	8	7		7		8	11	7	9	
		2	8	9	8		8		8	11	7	11	
		X̄	8	9	8	8	9		8	11	8	10	9
13. Holston River (N.F.) Saltville	Surface	1	15	11	8		5	NS	7	8	10	12	
		2	14	10	7		5		7	12	10	12	
	Bottom	1	15	22	11		4		7	13	10	11	
		2	22	8	11		4		9	12	10	6	
		X̄	17	13	9	13	5		8	11	10	10	9
14. Powell River Buchanan Ford	Surface	1	16	10	10		18	NS	5	19	34	14	
		2	16	13	9		24		8	20	36	13	
	Bottom	1	21	10	10		29		9	12	33	13	
		2	17	-	11		24		9	19	35	9	
		X̄	18	11	10	13	24		8	18	35	12	19
15. Powell River Fletcher Ford	Surface	1	15	9	5		19	NS	7	12	41	13	
		2	15	7	6		21		10	11	38	12	
	Bottom	1	15	7	7		19		5	13	38	12	
		2	14	7	5		23		6	12	47	23	
		X̄	15	8	6	9	21		7	12	41	15	19

*Sample lost in processing.
.NS = No sample collected.

Appendix H. Volatile Solids Data Collected from Surface and Near Bottom Depths of 15 Designated Study Reaches, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Study Reach	Location	Replicate	Volatile Solids (mg per liter)										
			1980				1981						
			July	August	Sept	X̄	April	May	June	July	August	Sept	X̄
1. Buffalo River	Surface	1	5	1	2		2	1	1	1	1*	1	
Metal Ford (1980)		2	2	2	1		2	3	1	1	1	1	
Topsy Bridge (1981)	Bottom	1	3	1	2		2	2	1	1	1*	1	
		2	-	1	2		2	2	1	1	2	1	
		X̄	3	1	2	2	2	2	1	1	1	1	1
2. Paint Rock River	Surface	1	3	2	5		1*	1	1*	1*	1*	1	
Estill Fork (1980)		2	4	1	7		1*	1	1*	1	1*	1*	
Mile 60.0 (1981)	Bottom	1	3	2	4		1*	1	1*	2	1*	1*	
		2	4	10	7		1*	1	1*	3	1	1*	
		X̄	4	4	6	4	1	1	1	2	1	1	1
3. Duck River	Surface	1	-	3	1		3	NS	2	3	2	2	
Lillards Mill		2	5	2	1		2		2	3	2	2	
	Bottom	1	-	4	2		2		2	3	2	1	
		2	6	3	2		3		-	3	2	1	
		X̄	6	3	2	3	3		2	3	2	2	2
4. Duck River	Surface	1	6	16	2		1	NS	4	3	5	3	
Sowell Ford		2	6	3	2		1		3	3	3	3	
	Bottom	1	6	4	4		1		3	3	1	2	
		2	6	4	3		1		3	3	3	2	
		X̄	6	7	3	5	1		3	3	3	3	3
5. Duck River	Surface	1	3	3	2		4	NS	3	2	6	2	
Halls Mill		2	3	3	2		1		3	2	8	2	
	Bottom	1	4	-	2		1		3	2	6	1	
		2	3	1	2		1		3	2	6	1	
		X̄	3	2	2	3	2		3	2	7	2	3

Appendix H. (Continued)

Study Reach	Location	Replicate	Volatile Solids (mg per liter)										
			1980				1981						
			July	August	Sept	X̄	April	May	June	July	August	Sept	X̄
6. Duck River	Surface	1	5	2	2		1	NS	2	5	4	5	
Dement Bridge		2	4	-	2		1		2	4	5	4	
	Bottom	1	4	2	2		1		2	5	4	5	
		2	4	-	2		1		2	5	5	4	
		X̄	4	2	2	3	1		2	5	5	5	3
7. Elk River	Surface	1	3	2	1		2	NS	5	5	4	3	
Chennault Ford (1980)		2	4	3	1		2		4	5	4	-	
Mile 91.4 (1981)	Bottom	1	3	2	1		2		5	5	3	4	
		2	3	2	1		2		4	5	3	3	
		X̄	4	2	1	2	2		5	5	4	3	5
8. Clinch River	Surface	1	5	4	4		1	NS	2	2	3	4	
Fort Blackmore		2	10	4	4		1		3	2	3	4	
	Bottom	1	6	3	4		1		3	2	4	4	
		2	5	4	4		3		2	2	4	4	
		X̄	7	4	4	5	2		3	2	4	4	3
9. Clinch River	Surface	1	3	9	2		1	NS	1	2	4	5	
Kyles Ford		2	3	2	2		2		2	2	4	5	
	Bottom	1	2	6	2		2		2	2	4	5	
		2	3	3	2		2		1	2	4	5	
		X̄	3	5	2	3	2		2	2	4	5	3
10. Copper Creek	Surface	1	3	2	2		1	NS	2	2	2	2	
Mile 7.7 (1980)		2	2	2	2		1		2	3	2	2	
Mile 1.9 (1981)	Bottom	1	3	1	2		1		2	3	2	2	
		2	3	2	2		1		1	3	3	2	
		X̄	3	2	2	2	1		2	3	2	2	2

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Appendix H. (Continued)

Study Reach	Location	Replicate	Volatile Solids (mg per liter)										
			1980				1981						
			July	August	Sept	X̄	April	May	June	July	August	Sept	X̄
11. Nolichucky River Hale Bridge	Surface	1	6	-	2		4	NS	2	3	2	2	
		2	5	3	2		4		3	3	2	2	
	Bottom	1	5	3	2		3		2	3	2	2	
		2	7	3	2		4		2	3	2	2	
		X̄	6	3	2	4	4		2	3	2	2	3
12. Holston River (N.F.) Click Island	Surface	1	2	1	1		1	NS	1	2	1	2	
		2	2	1	1		2		1	1	1	2	
	Bottom	1	1	1	1		1		1	1	1	2	
		2	2	9	1		2		1	1	1	2	
		X̄	2	3	1	2	2		1	1	1	2	1
13. Holston River (N.F.) Saltville	Surface	1	3	2	2		1	NS	1	1	1	2	
		2	4	2	2		1		1	2	3	2	
	Bottom	1	4	2	2		1		1	2	3	2	
		2	4	2	2		1		4	2	2	1	
		X̄	4	2	2	3	1		2	2	2	2	2
14. Powell River Buchanan Ford	Surface	1	3	1	1		2	NS	1	3	4	2	
		2	3	2	1		4		1	3	5	2	
	Bottom	1	3	1	2		4		1	2	4	2	
		2	3	-	2		3		1	3	4	1	
		X̄	3	1	2	2	3		1	3	4	2	3
15. Powell River Fletcher Ford	Surface	1	3	1	1		3	NS	1	2	4	2	
		2	3	7	1		3		2	2	5	2	
	Bottom	1	3	1	1		2		1	2	5	2	
		2	3	7	1		3		1*	2	5	3	
		X̄	3	4	1	3	3		1	2	5	2	3

*Value F1, MDL of 1.0 assumed.
.Sample lost.

:NS = No sample collected.

Appendix I. Total Periphyton Abundance (no./cm^2 x 10^3), Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Reach	Replicate	1980 July	Sept	$\bar{X}$	1981 May	June	July	Sept	$\bar{X}$
1. Buffalo River	1	586.5	1,387.5		36.3	NS*	198.8	213.8	
Metal Ford (1980)	2	1,428.2	1,151.4		37.2		179.5	79.4	
Topsy Bridge (1981)	3	916.9	901.5		42.3		173.5	63.9	
	$\bar{X}$	977.2	1,146.8	1,062.0	38.6		183.9	119.0	113.9
2. Paint Rock River	1	1,212.5	983.6		1,394.7	NS	123.6	11.6	
Estill Fork (1980)	2	1,059.3	1,087.6		1,431.9		117.3	9.8	
Mile 60.0 (1981)	3	1,401.2	956.9		882.0		125.5	10.9	
	$\bar{X}$	1,224.3	1,009.4	1,116.9	1,236.2		122.1	10.8	456.4
3. Duck River	1	320.6	1,152.9		NS	10,083.2	115.7	53.4	
Lillards Mill	2	484.3	354.4			10,341.9	117.9	62.5	
	3	240.3	2,803.1			1,218.1	95.8	46.5	
	$\bar{X}$	348.4	1,436.8	892.6		7,214.4	109.8	54.1	2,459.4
4. Duck River	1	239.6	1,140.5		NS	77.6	37.7	46.5	
Sowell Ford	2	394.3	108.6			308.8	83.6	47.9	
	3	936.1	630.1	574.9		2,677.9	70.8	30.9	
	$\bar{X}$	523.3	626.4			1,021.4	64.0	41.8	375.7
5. Duck River	1	1,818.3	107.9		NS	211.4	90.3	8.4	
Halls Mill	2	362.0	101.8			255.9	117.0	5.3	
	3	2,066.1	176.9			56.7	16.7	10.0	
	$\bar{X}$	1,415.5	128.9	772.2		174.7	74.7	7.9	85.7
6. Duck River	1	277.8	54.4		NS	208.5	12.3	19.1	
Dement Bridge	2	75.7	356.3			541.5	29.9	39.2	
	3	75.1	230.1			214.7	98.2	15.0	
	$\bar{X}$	142.9	213.6	178.2		321.6	46.8	24.4	130.9
7. Elk River	1	769.1	95.1		NS	628.2	174.9	289.7	
Chennault Ford (1980)	2	631.0	147.0			306.8	151.2	68.6	
Mile 91.4 (1981)	3	259.7	56.5			208.5	151.5	125.4	
	$\bar{X}$	553.3	99.5	326.4		381.2	159.2	161.2	233.9

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Appendix I. (Continued)

Reach	Replicate	1980 July	1980 Sept	1980 $\bar{X}$	1981 May	1981 June	1981 July	1981 Sept	1981 $\bar{X}$
8. Clinch River	1	1,031.2	226.9		NS	247.0	26.4	77.5	
Fort Blackmore	2	793.6	289.2			315.5	54.1	29.4	
	3	293.8	113.7			281.3	54.0	32.4	
	$\bar{X}$	706.2	209.9	458.1		281.3	44.8	46.4	124.2
9. Clinch River	1	2,100.9	167.9		NS	340.8	7.3	1.3	
Kyles Ford	2	1,960.9	86.1			332.7	6.9	1.6	
	3	1,910.4	324.5			373.2	14.1	2.5	
	$\bar{X}$	1,990.7	192.8	1,091.8		348.9	9.4	1.8	120.0
10. Copper Creek	1	1,407.7	108.1		NS	186.5	5.0	85.0	
Mile 7.7 (1980)	2	455.4	194.7			200.8	8.9	77.0	
Mile 1.9 (1981)	3	481.0	391.1			181.7	57.9	88.6	
	$\bar{X}$	781.4	231.3	506.3		189.7	23.9	83.5	99.0
11. Nolichucky River	1	244.0	55.2		NS	708.4	84.5	103.5	
Hale Bridge	2	166.2	87.0			640.5	110.4	96.1	
	3	295.6	231.4			697.4	99.1	85.9	
	$\bar{X}$	228.6	124.5	176.6		682.1	98.0	95.2	291.8
12. Holston River (N.F.)	1	135.0	46.8		NS	128.9	170.4	63.9	
Click Island	2	148.8	8.1			143.0	124.2	52.5	
	3	245.6	17.2			99.1	137.2	44.4	
	$\bar{X}$	176.5	24.0	100.3		123.7	143.9	53.6	107.1
13. Holston River (N.F.)	1	1,775.2	331.5		NS	632.9	303.0	32.8	
Saltville	2	466.9	231.8			480.6	243.3	12.2	
	3	1,461.3	458.9			538.1	237.1	3.2	
	$\bar{X}$	1,234.5	340.7	787.6		550.5	261.1	16.1	275.9
14. Powell River	1	474.8	494.5		NS	65.1	121.9	446.0	
Buchanan Ford	2	418.2	262.1			43.3	105.0	520.1	
	3	491.1	77.5			25.2	113.9	432.5	
	$\bar{X}$	461.4	278.0	369.7		44.5	113.6	466.2	208.1

Appendix I. (Continued)

Reach	Replicate	1980 July	1980 Sept	1980 $\bar{X}$	1981 May	1981 June	1981 July	1981 Sept	1981 $\bar{X}$
15. Powell River Fletcher Ford	1	554.5	329.3		NS	722.5	61.6	101.3	
	2	789.4	136.6			459.7	68.4	105.2	
	3	751.1	313.6			-†	62.4	95.7	
	$\bar{X}$	698.3	259.8	479.1		591.1	64.1	100.7	209.6

*No survey conducted

†Sample unpreserved and not processed

Appendix J. Periphyton Abundance (no./cm^2 x 10^3) by Group, Cumberlandian Mollusk Conservation Program, 1980 and 1981.

Reach	Periphyton Groups	Replicate	1980 July	1980 Sept	1980 $\bar{X}$	1981 May	1981 July	1981 Sept	1981 $\bar{X}$
1. Buffalo River Metal Ford (1980) Topsy Bridge (1981)	Chlorophyta	1	9.9	10.1		27.2	1.3	1.2	
		2	30.1	14.0		20.0	1.6	2.4	
		3	4.3	13.4		16.5	0.8	0.1	
		$\bar{X}$	14.8	12.5	13.6	21.2	1.2	1.2	7.9
	Chrysophyta	1	141.2	308.9		9.1	126.1	141.8	
		2	70.3	249.4		16.0	125.5	44.1	
		3	68.0	153.8		16.8	121.2	46.1	
		$\bar{X}$	93.2	237.4	165.3	14.0	124.3	77.3	71.9
	Cyanophyta	1	435.4	1,068.5		0.0	71.3	70.8	
		2	1,327.8	888.0		1.3	52.4	32.9	
		3	844.5	734.3		9.0	51.8	17.7	
		$\bar{X}$	869.2	896.9	883.1	3.4	58.5	40.5	34.1
2. Paint Rock River Estill Fork (1980) Mile 60.0 (1981)	Chlorophyta	1	14.1	158.7		261.9	11.5	0.7	
		2	45.5	119.4		277.7	11.0	0.0	
		3	70.0	96.7		149.4	6.4	1.6	
		$\bar{X}$	43.2	124.9	84.1	229.7	9.6	0.8	80.0
	Chrysophyta	1	22.3	82.3		591.5	69.4	9.1	
		2	50.2	70.0		571.8	60.6	8.5	
		3	40.1	59.9		410.3	80.7	7.5	
		$\bar{X}$	37.5	70.7	54.1	524.5	70.2	8.4	201.0
	Cryptophyta	1	0.3	0.0		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	Cyanophyta	1	1,175.9	742.5		541.3	42.7	1.8	
		2	963.6	898.2		582.3	45.7	1.2	
		3	291.2	800.3		322.3	38.4	1.8	
		$\bar{X}$	810.2	813.7	812.0	482.0	42.3	1.6	175.3

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980 July	Sept	$\bar{X}$	1981 June	July	Sept	$\bar{X}$
3. Duck River Lillards Mill	Chlorophyta	1	4.5	47.9		9,368.9	30.7	13.8	
		2	6.1	6.0		33.9	27.8	11.3	
		3	7.3	141.3		21.7	30.0	4.5	
		$\bar{X}$	6.0	65.1	35.6	3,141.5	29.5	9.9	1,060.3
	Chrysophyta	1	3.0	7.8		80.1	3.1	15.9	
		2	3.1	8.4		9,428.6	8.4	21.0	
		3	2.1	5.8		64.5	5.3	19.8	
		$\bar{X}$	2.7	7.3	5.0	3,191.1	5.6	18.9	1,071.9
	Cryptophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	1.5	0.0		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.5	0.0	0.3	0.0	0.0	0.0	0.0
	Cyanophyta	1	315.8	1,097.3		634.0	82.0	23.8	
		2	474.9	340.0		879.4	81.7	30.2	
		3	230.9	2,655.9		1,131.9	60.5	22.3	
		$\bar{X}$	340.5	1,364.4	852.5	881.8	74.7	25.4	327.3
	Euglenophyta	1	0.0	0.0		0.2	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.0	0.0	0.1	0.0	0.0	0.0
4. Duck River Sowell Ford	Chlorophyta	1	7.3	52.6		3.0	4.0	3.1	
		2	54.7	8.5		1.1	2.8	3.6	
		3	39.9	11.8		7.2	3.1	1.3	
		$\bar{X}$	40.0	24.3	32.2	3.2	3.3	2.7	3.1
	Chrysophyta	1	4.3	35.1		7.3	6.9	12.9	
		2	14.1	11.5		9.9	3.1	25.5	
		3	1.2	19.3		5.8	5.2	16.5	
		$\bar{X}$	6.5	22.0	14.3	7.7	5.1	18.3	10.1

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980			1981			
			July	Sept	$\bar{X}$	June	July	Sept	$\bar{X}$
4. Duck River (Continued)	Cyanophyta	1	228.0	1,052.7		67.3	26.8	30.5	
		2	325.4	88.5		297.9	77.7	18.9	
		3	894.8	599.0		2,664.9	62.5	13.1	
		$\bar{X}$	482.7	580.1	531.4	1,010.0	55.7	20.8	362.2
	Euglenophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	0.1	0.0		0.0	0.0	0.0	
		3	0.2	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.1	0.0	0.1	0.0	0.0	0.0	0.0
5. Duck River Halls Mill	Chlorophyta	1	122.0	7.4		5.5	2.1	0.7	
		2	2.8	3.9		7.2	4.4	0.2	
		3	124.9	15.3		20.2	0.4	2.3	
		$\bar{X}$	83.2	8.9	46.1	11.0	2.3	1.1	4.8
	Chrysophyta	1	0.0	8.2		11.5	8.3	7.7	
		2	0.4	4.5		9.4	2.9	5.1	
		3	2.1	4.6		4.6	1.7	4.7	
		$\bar{X}$	0.8	5.6	3.2	8.5	4.3	5.8	6.2
	Cyanophyta	1	1,696.3	92.3		194.4	79.9	0.0	
		2	358.9	93.5		239.3	109.7	0.0	
		3	1,939.1	157.0		31.9	14.6	3.1	
		$\bar{X}$	1,331.4	114.3	722.9	155.2	68.1	1.0	74.8
6. Duck River Dement Bridge	Chlorophyta	1	60.6	3.3		8.1	2.2	8.8	
		2	15.1	4.8		0.0	1.8	11.5	
		3	17.6	10.5		6.3	0.8	5.9	
		$\bar{X}$	31.1	6.2	18.7	4.8	1.6	8.7	5.0
	Chrysophyta	1	18.8	41.6		50.8	3.9	3.1	
		2	16.3	21.4		13.5	4.3	3.9	
		3	13.2	36.6		14.1	2.9	1.1	
		$\bar{X}$	16.1	33.2	24.7	26.1	3.7	2.7	10.8
	Cyanophyta	1	168.4	9.6		149.5	6.2	7.3	
		2	44.3	330.2		528.0	23.8	23.8	
		3	44.3	183.0		194.4	94.5	7.9	
		$\bar{X}$	85.7	174.3	130.0	290.6	41.5	13.0	115.0

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980			1981			
			July	Sept	X̄	June	July	Sept	X̄
7. Elk River Chennault Ford (1980) Mile 91.4 (1981)	Chlorophyta	1	29.5	11.8		157.8	5.9	77.3	
		2	122.2	13.9		53.4	8.3	27.9	
		3	23.9	2.1		51.7	7.5	28.6	
		X̄	58.5	9.3	33.9	87.6	7.2	44.6	46.5
	Chrysophyta	1	39.3	18.7		3.1	34.3	11.2	
		2	84.2	48.2		4.6	26.4	5.0	
		3	38.4	35.3		10.9	25.4	5.4	
		X̄	54.0	34.1	44.1	6.2	28.7	7.2	14.0
	Cyanophyta	1	700.4	64.6		467.3	134.7	201.2	
		2	424.7	84.9		248.8	116.5	35.7	
		3	197.4	19.1		145.8	118.6	91.5	
		X̄	440.8	56.2	248.5	287.3	123.3	109.5	173.4
8. Clinch River Fort Blackmore	Chlorophyta	1	111.9	44.8		2.6	6.9	11.9	
		2	131.1	91.0		43.1	11.4	16.0	
		3	46.8	48.5		45.3	3.7	9.8	
		X̄	96.6	61.4	79.0	30.3	7.3	12.6	16.7
	Chrysophyta	1	6.4	54.7		206.8	4.0	16.4	
		2	8.5	79.0		171.6	2.3	3.7	
		3	3.1	40.3		164.4	5.5	8.6	
		X̄	6.0	58.0	32.0	180.9	3.9	9.6	64.8
	Cyanophyta	1	912.7	127.3		37.6	15.6	49.3	
		2	650.0	118.9		100.8	40.4	9.8	
		3	244.0	25.0		71.7	44.8	14.0	
		X̄	602.2	90.4	346.3	70.0	33.6	24.4	42.7
	Euglenophyta	1	0.2	0.0		0.0	0.0	0.0	
		2	0.2	0.2		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		X̄	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980 July	1980 Sept	1980 $\bar{X}$	1981 June	1981 July	1981 Sept	1981 $\bar{X}$
8. Clinch River (Continued)	Rhodophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	3.8	0.0		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	1.3	0.0	0.7	0.0	0.0	0.0	0.0
	Pyrrophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	0.0	0.2		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.1	0.1	0.0	0.0	0.0	0.0
9. Clinch River Kyles Ford	Chlorophyta	1	1,187.9	152.1		43.5	1.3	0.0	
		2	1,002.3	58.4		50.2	0.8	0.0	
		3	952.9	299.1		33.4	0.8	1.5	
		$\bar{X}$	1,047.7	169.9	608.8	42.4	1.0	0.5	14.6
	Chrysophyta	1	28.7	2.1		72.9	4.2	1.2	
		2	36.4	6.7		79.5	3.0	1.6	
		3	31.7	5.5		81.3	5.1	1.0	
		$\bar{X}$	32.3	4.8	18.6	77.9	4.1	1.3	27.8
	Cryptophyta	1	0.0	0.1		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.0	0.2		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.1	0.1	0.0	0.0	0.0	0.0
	Cyanophyta	1	884.3	13.6		224.4	1.8	0.0	
		2	922.1	21.0		203.1	3.1	0.0	
		3	925.8	19.7		258.6	8.2	0.0	
		$\bar{X}$	910.7	18.1	464.4	228.7	4.4	0.0	77.7
	Euglenophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980			1981			
			July	Sept	X̄	June	July	Sept	X̄
10. Copper Creek Mile 7.7 (1980) Mile 1.9 (1981)	Chlorophyta	1	44.5	3.5		0.0	0.6	12.8	
		2	20.0	61.3		10.5	0.2	7.2	
		3	0.6	52.5		0.0	3.2	13.1	
		X̄	21.7	39.1	30.4	3.5	1.3	11.0	5.3
	Chrysophyta	1	61.4	74.9		176.6	4.5	21.0	
		2	39.8	71.8		178.1	7.5	20.3	
		3	66.0	209.0		171.7	51.3	30.9	
		X̄	55.7	118.6	87.2	175.5	21.1	24.1	73.6
	Cyanophyta	1	1,301.6	29.6		9.8	0.0	51.2	
		2	392.5	60.8		12.2	1.2	50.0	
		3	397.6	129.6		9.8	3.4	44.5	
		X̄	697.2	73.3	385.3	10.6	1.5	48.6	20.2
	Euglenophyta	1	0.2	0.0		0.2	0.0	0.0	
		2	0.2	0.3		0.0	0.0	0.0	
		3	0.2	0.0		0.3	0.0	0.0	
		X̄	0.2	0.1	0.2	0.2	0.0	0.0	0.1
	Rhodophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	3.1	0.0		0.0	0.0	0.0	
		3	16.6	0.0		0.0	0.0	0.0	
		X̄	6.6	0.0	3.3	0.0	0.0	0.0	0.0
11. Nolichucky River Hale Bridge	Chlorophyta	1	6.2	0.8		55.4	1.4	6.1	
		2	32.0	9.6		51.4	1.7	4.9	
		3	0.9	62.0		68.2	0.0	3.9	
		X̄	13.0	24.1	18.6	58.3	1.0	5.0	21.4
	Chrysophyta	1	4.5	8.8		91.9	29.8	48.6	
		2	4.2	26.0		75.6	20.6	48.2	
		3	2.1	20.5		79.1	20.5	46.0	
		X̄	3.6	18.4	11.0	82.2	23.6	47.6	51.1

Appendix J. (Continued)

	Periphyton		1980			1981			
Reach	Groups	Replicate	July	Sept	$\bar{X}$	June	July	Sept	$\bar{X}$
11. Nolichucky River (Continued)	Cryptophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.1	0.2		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.1	0.1	0.0	0.0	0.0	0.0
	Cyanophyta	1	1,301.6	29.6		561.1	53.5	48.8	
		2	392.5	60.8		513.5	88.1	43.0	
		3	397.6	129.6		550.1	78.7	36.0	
		$\bar{X}$	697.2	73.3	385.3	541.6	73.4	42.6	219.2
	Euglenophyta	1	0.0	0.1		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.1	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pyrrophyta	1	0.0	0.1		0.0	0.0	0.0	
		2	0.1	0.0		0.0	0.0	0.0	
		3	0.0	0.1		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.1	0.1	0.0	0.0	0.0	0.0
12. Holston River (N.F.) Click Island	Chlorophyta	1	95.4	43.6		1.1	9.6	5.0	
		2	91.8	5.0		3.8	6.3	5.2	
		3	152.5	9.1		0.0	9.0	4.2	
		$\bar{X}$	113.2	19.2	66.2	1.6	8.3	4.8	4.9
	Chrysophyta	1	3.5	3.2		52.7	29.2	7.9	
		2	1.9	1.2		58.7	45.9	7.2	
		3	0.8	2.1		40.0	36.5	6.9	
		$\bar{X}$	2.1	2.2	2.2	50.5	37.2	7.3	31.7
	Cyanophyta	1	36.0	0.0		75.0	131.5	51.1	
		2	55.1	1.8		80.5	72.0	40.1	
		3	92.3	5.9		59.1	91.8	33.2	
		$\bar{X}$	61.1	2.6	31.9	71.5	98.4	41.5	70.5

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980 July	1980 Sept	1980 $\bar{X}$	1981 June	1981 July	1981 Sept	1981 $\bar{X}$
12. Holston River (Continued)	Euglenophyta	1	0.1	0.0		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.1	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.1	0.0	0.1	0.0	0.0	0.0	0.0
	Pyrrophyta	1	0.0	0.0		0.0	0.0	0.0	
		2	0.0	0.1		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13. Holston River (N.F.) Saltville	Chlorophyta	1	129.6	138.8		220.8	176.7	6.3	
		2	69.7	138.3		171.8	125.1	5.3	
		3	35.8	152.2		196.5	133.4	1.5	
		$\bar{X}$	78.4	143.1	110.8	196.4	145.1	4.4	115.3
	Chrysophyta	1	29.6	31.6		91.3	10.5	14.9	
		2	8.1	11.6		55.0	12.4	6.9	
		3	22.7	25.6		73.2	11.7	1.7	
		$\bar{X}$	20.1	22.9	21.5	73.2	11.5	7.8	30.8
	Cryptophyta	1	0.0	0.2		0.0	0.0	0.0	
		2	0.0	0.2		0.0	0.0	0.0	
		3	0.0	0.2		0.0	0.0	0.0	
		$\bar{X}$	0.0	0.2	0.1	0.0	0.0	0.0	0.0
	Cyanophyta	1	1,615.9	161.0		320.8	115.8	11.7	
		2	389.1	81.7		253.7	108.8	0.0	
		3	1,402.7	280.9		268.3	92.1	0.0	
		$\bar{X}$	1,135.9	174.5	655.2	280.9	105.6	3.9	130.1
	Euglenophyta	1	0.2	0.0		0.0	0.0	0.0	
		2	0.0	0.0		0.0	0.0	0.0	
		3	0.0	0.2		0.0	0.0	0.0	
		$\bar{X}$	0.1	0.1	0.1	0.0	0.0	0.0	0.0

Appendix J. (Continued)

Reach	Periphyton Groups	Replicate	1980			1981			
			July	Sept	X̄	June	July	Sept	X̄
14. Powell River Buchanan Ford	Chlorophyta	1	92.6	246.2		6.3	45.3	261.6	
		2	114.5	182.2		2.0	34.1	281.5	
		3	121.5	39.9		4.3	45.2	238.5	
		X̄	109.5	156.1	132.8	4.2	41.5	260.5	102.1
	Chrysophyta	1	2.4	29.9		13.0	5.2	13.0	
		2	1.7	32.9		8.4	5.1	15.4	
		3	2.4	9.6		20.8	9.6	12.9	
		X̄	2.2	24.1	13.2	14.1	6.6	13.8	11.5
	Cryptophyta	1	0.0	0.3		0.0	0.0	0.0	
		2	0.0	0.2		0.0	0.0	0.0	
		3	0.0	0.0		0.0	0.0	0.0	
		X̄	0.0	0.2	0.1	0.0	0.0	0.0	0.0
	Cyanophyta	1	379.8	218.0		45.7	71.3	171.4	
		2	302.0	46.8		32.9	65.8	223.2	
		3	367.1	28.0		0.0	59.1	181.1	
		X̄	349.6	97.6	223.6	26.2	65.4	191.9	94.5
15. Powell River Fletcher Ford	Chlorophyta	1	118.4	171.7		188.0	12.9	3.7	
		2	179.7	81.3		117.3	11.2	5.8	
		3	147.9	234.0		-*	5.1	5.3	
		X̄	148.7	162.3	155.5	152.7	9.7	4.9	43.7
	Chrysophyta	1	3.4	19.5		14.9	12.2	26.3	
		2	7.3	1.7		13.4	9.3	27.9	
		3	11.6	5.0		-	12.5	23.9	
		X̄	7.4	8.7	8.1	14.2	11.3	26.0	17.6
	Cyanophyta	1	432.7	138.1		519.6	36.6	71.3	
		2	602.4	53.7		329.0	47.9	71.6	
		3	591.6	74.6		-	44.8	66.5	
		X̄	542.2	88.8	315.5	424.3	43.1	69.8	148.4

*No survey conducted